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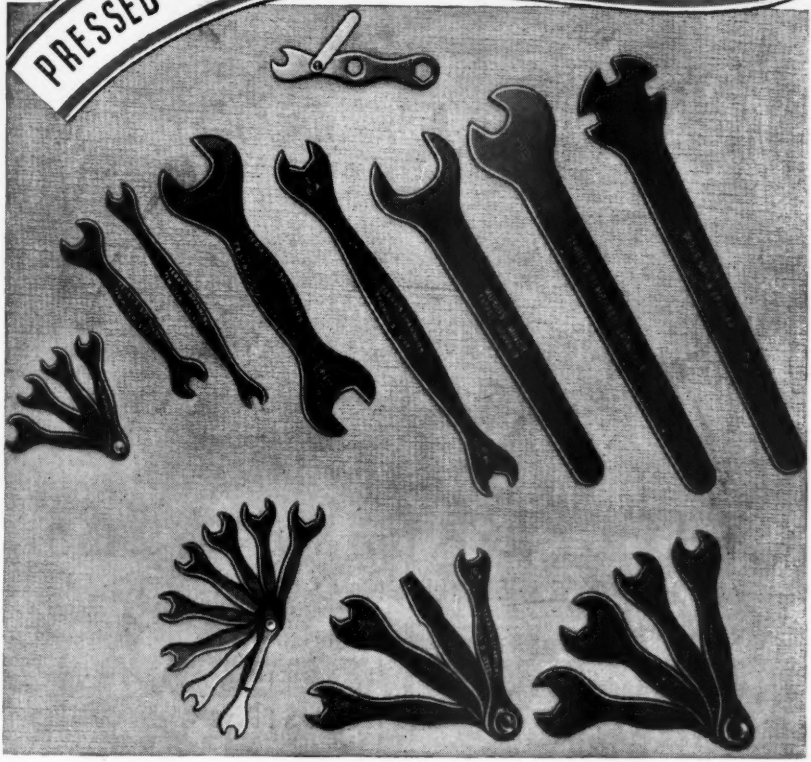

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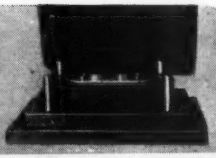

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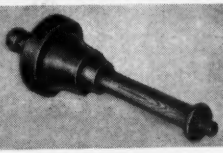

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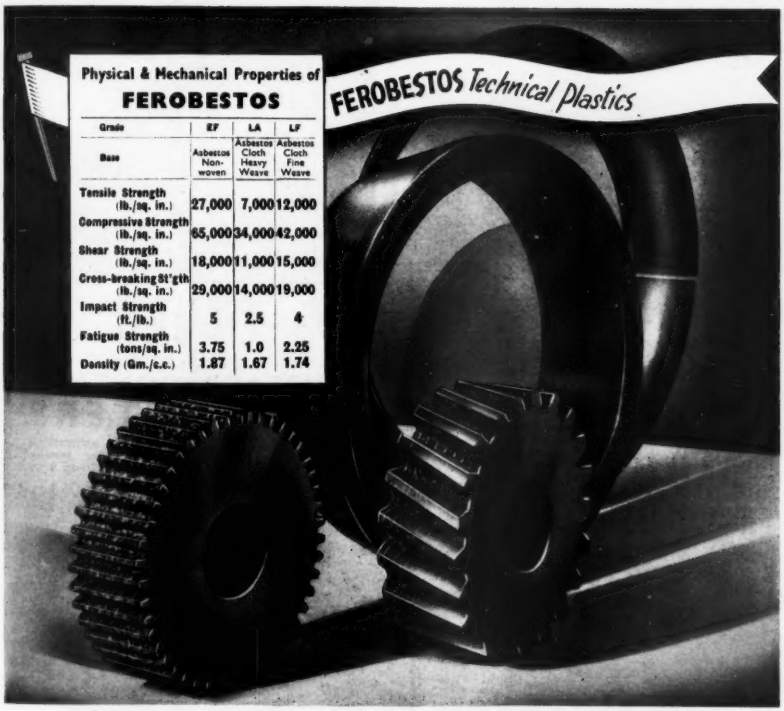

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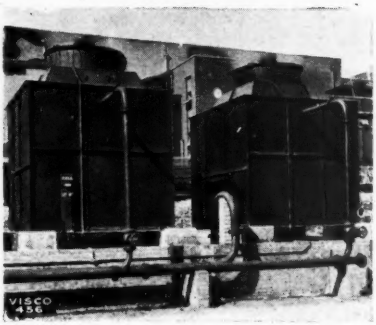

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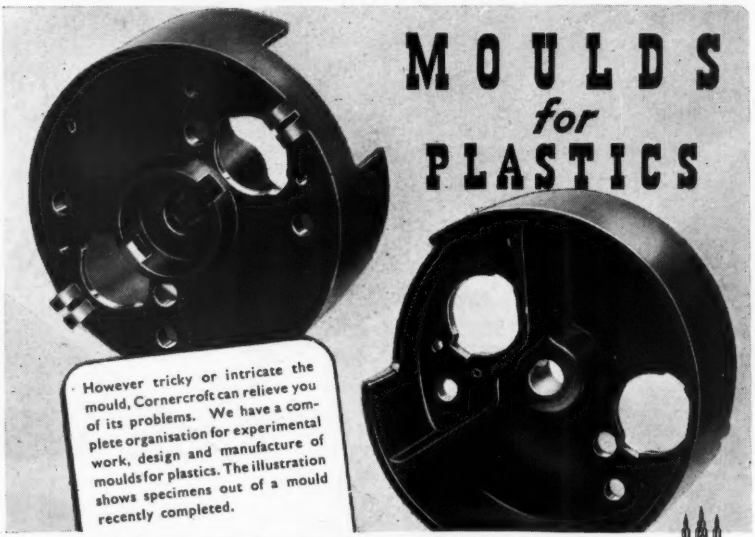

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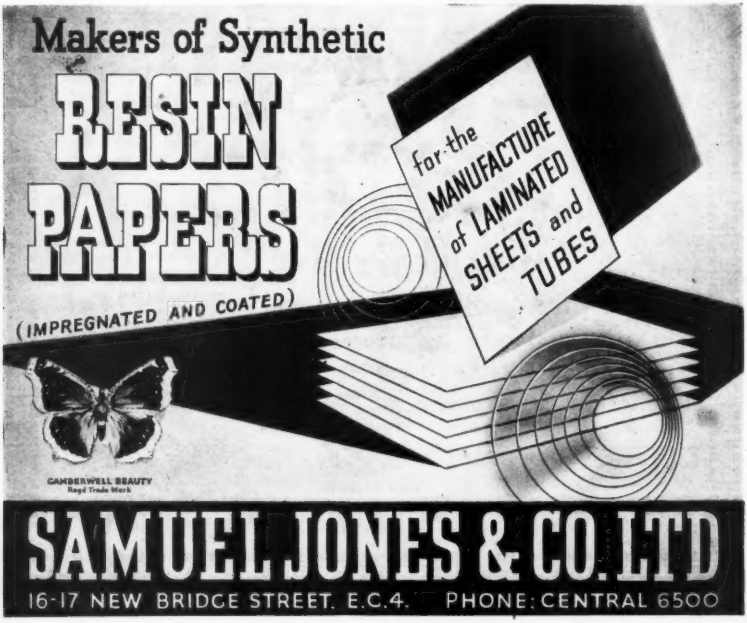
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Vol. X. No. 105 FEBRUARY, 1946

Plastics

Dealing with the Manufacture, Uses and Potentialities of Plastic Materials

Proprietors - - TEMPLE PRESS LIMITED
Managing Director - ROLAND E. DANGERFIELD

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NOTICES

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EDITORIALS

On Shaping Plastic Sheet

BEFORE the war the number of transparent plastic sheet manipulating factories could, without great exaggeration, be counted on the fingers of two hands Some of them were directly or indirectly connected with optical concerns, some made advertising displays, letterings and a variety of objects ranging from transparent food covers to horticultural cloches.

This section of the industry was in its infancy, although some had already begun to do quite useful and important work for aircraft. As soon as war broke out all turned over to the making of aircraft parts, turrets, chutes, ventilators, discs and domes, tanks and so forth from cellulose acetate and methyl methacrylate, the latter now far better known by the trade name " Perspex."

The number of companies carrying out this work increased considerably and rapidly during the past six years, for the process needed little plant: a gas or air-heated chamber, air-pressure supply, the means for making wooden formers and drilling, sawing or other simple cutting machines were all that was necessary from the mechanical point of view. The key man was the jig or form maker, and, indeed, the skill and ingenuity of the carpenters in such factories was often a thing to marvel at and to be proud of. As for the finished jobs in plastics, experience and M.A.P. and M.O.S. specifications created a skill and accuracy which should prove a good basis for future endeavours.

Having said this, however, we must examine the new scene that faces these factories.

Work for aircraft has almost completely disappeared, all the factories have turned over to peace-time production and have joined in the game of supplying the enormous demand for articles ranging from cigarette boxes to salad bowls, the only limiting factor being the unfortunate drop in the amount of sheet now available for fabrication.

There is a still more unfortunate state of affairs prevailing. Heaven knows that we need no high-speed sales agents to sell our goods to-day, for the country is hungry for anything and will pay almost anything for it.

But all this is no excuse for thrusting upon the world such crude things as we have seen in recent days.

Some workers are using the very jigs they used for making aircraft astral domes, turning the result upside down, sticking on a base with a solvent of deadly secret composition, and lo! they have created a flower bowl. Like stout Cortez, they see new continents before them, ripe for plucking. Or a cigarette box is thrust upon a boxless world with great acclaim, but of a design so poor that the little Cockney boys of fourteen we used to see working in Mr. Woodiwiss's East-end school before the war would turn up their noses in disdain. Indeed, some of the new workers do not realize that the only beauty in these bowls and boxes is the beauty of the " Perspex " itself.

We repeat that, technically, the work is often perfection itself. As works of art, the greatest proportion of the objects made are appalling flops.

The fabricators from these plastic sheets have in their hands the making of a new little yet important industry; but if they imagine they will succeed merely by copying one another's crude designs, or if they conclude that, because they have been turning out thousands of double curvature turrets, they can in the twinkling of an eye switch over to a development dependent more on artistic design than on technical worth, then they are in

for a shock. Sooner or later they will encounter competition of such merit (we refer to competition from Europe, especially France, where æsthetic appreciation is almost inborn and the huge State-fostered industrial art schools feed the new plastic industries) that their own efforts will scarcely reach the markets.

If, however, British fabricators will awake and realize that it is no use asking the jig-maker for his opinion as to the design of an object destined to dazzle the eyes of the ladies of Buenos Aires or of Calcutta, or, for that matter, of Manchester and London, if he will take an hour off to visit the Victoria and Albert Museum, and if then he has gained an insight of the supreme function of design, he is at least at the beginning of the right road.

The artist and trained designer *must* take charge of design, and, fortunately, some of the fabricators realize it.

Film News

ON another page in this issue a representative of the cinema industry gives us some news of the interest there in plastics, and the information that experts in our materials may be employed to advise on the subject is at least intriguing.

We ourselves, as chronic film-goers of very catholic taste, ranging from profound respect of Mr. Orson Welles and Mr. Robert Hope to a devotion of Miss Rosalind Russell and Senorita Carmen Miranda, view any means of embellishing cinematic technique apart from the purely mechanical aspect of it with considerable enthusiasm.

The impact of plastics on film scenic architecture has always interested us enormously, and ever since we saw H. G. Wells's "Shape of Things to Come" (which beat the Americans to it in a spectacular use of transparent acetate sheet transformed into gigantic tubular shapes), we have wondered how far the process can go.

We are in thorough agreement with Mr. Paterson's assertion that whatever the screen does show of plastics will rouse tremendous interest in it by the public, and, without doubt, will increase the demand.

There may be just one exception, so far as this country is concerned. No doubt every male American, following the methods of his special film hero, boldly enters a flower shop, hands over a bunch of dollar bills, carries away a six-foot long "Cellophane" or acetate box of choice orchids and presents them to his lady friend without batting an eyelid. Even if he bats an eyelid it is done deliberately. An Englishman (synonym: cold fish), on the other hand, would rather be seen dead than buy even a bob bunch of violets for his lady love. Or, if he does, he generally puts on a beard to pretend he is a foreigner. No, we do not expect the British flower industry to thrive overmuch because of plastics.

It is important to note that, so far, the cinema is only affected by transparent plastics, and while we shall probably have more "miracle" films and many more dancing ladies with transparent hats or bags or shoes or skirts, and many more banana trees with transparent leaves for artistic backgrounds, is it at all likely that any other plastic will be used?

Our own opinion is that transparency is the only exciting thing that can be shown on the screen. This is important enough, and we may yet see much interesting scientific, especially medical, work described by its aid. But it is another thing entirely to put opaque plastics across so simply, and we are not sure that it can be done at all.

Perhaps we have already met the first attempt. Let us tell you about it.

Hollywood has recently manufactured, perhaps we should say extruded, a film entitled "Love Letters." Better critics than ourselves have commented on this extraordinary production, but none has so far mentioned something that we noticed. The scene is in an Essex garden (Essex, Eng., not Essex, Okla., mark you). The date is June 21, for the heroine has just told the hero so, and hanging from the trees are apples the size of young

melons, and just thrown in for luck, the blossoms are in full bloom at the same time.

Now, we in Essex are very proud of our fruit—the Darcy Spice apple and greengages are hard to beat, but we never allow them to ripen before August, September or October, and insist on blossom coming long before the fruit is ripe.

This need not worry us over much since we are now sure that, in order to attain a delicate symbolism, Mr. Sam Goldwyn himself blew a lot of apples by the new moulding technique.

P.V.C.

OUR remarks last month on the P.V.C. racket brought forth a large correspondence from many who had been bitten and a few from others anxious to join the merry throng of black-marketeers.

At this point, we wish to make it clear that our remarks only referred, and could only refer, to the sale of plain calendered polyvinyl chloride sheet. Once the material is worked into raincoats, bags or shoes, there may be "rackets," but we have no means of estimating the extent of a reasonable profit.

It is interesting to note that scrap P.V.C. is being bought up and is re-calendered for the market. Economically, there is nothing against this practice. Indeed, we can supply sufficient reasons why it is commendable—we should object to such valuable material being completely wasted. But, in view of the fact that much of the waste must be dirty and since it must be re-calendered or extruded generally with the addition of more plasticizer, there is definitely the necessity for some measure of control. As we have already pointed out in these pages, scrap P.V.C., contaminated with dirt and compounded with the wrong plasticizers, is not the best material to use for making babies' "napkins." Moreover, since the public cannot tell the difference between new and scrap P.V.C. (indeed, it would often tax many "experts" to do so), we have here the makings of a fine price racket. In more normal times we should be faced with another problem, namely, that scrap P.V.C. might force the legitimate price of new P.V.C. down below what may be called an economic level. This tendency may yet take place since, depending on the manufacture, scrap can be a large proportion of production. This points to a desirable control by the manufacturers of new P.V.C. which, if fairly maintained, would guide the scrap back to themselves or to reputable concerns for re-calendering.

There is also evidence that a very poor quality material, which tends to stick together and anything else on which the wearer sits, is being made. This may be the result of calendering from scrap with too much plasticizer, and is certainly another argument for closer control.

One manufacturer of P.V.C. raincoats has complained bitterly that even the best sheet often varies in thickness, and on examining some of his material we noted a variation between 8/1000 and 11/1000. This he knows is not a deception, since he buys by weight, which is the fairest way; but it leads to unevenness in production. He wishes to know whether it can be produced to very close tolerances. This we doubt and, indeed, cannot regard a variation of 3/1000 to be excessive.

The same manufacturer has evolved a new method of stitching the material and sewing buttons, which, to our mind, answers all the criticisms we made against this method of joining P.V.C.

German Industries

THE industrial penalties recently announced that Germany will pay for her past deeds far exceeds any financial or other indemnity she will make.

The Germans will be forced to abandon absolutely the production of synthetic petrol, rubber and ammonia, raw aluminium and magnesium, heavy machine tools and anti-friction bearings. No exports of sulphuric acid, chlorine, carbide, methanol and nitrogen will be allowed. She will be permitted to export coal and coke, toys, electrical equipment,

musical instruments, wines, spirits and beer, potash, textiles and apparel.

Thus at one stroke Germany's great chemical industry, perhaps the most important single factor backing her war-effort, comes tumbling down to a low level. We will shed not a single tear, although we shall remember some of its great scientists and the good that might have come from it all had greed for world power not blinded that nation.

Those of our readers who peruse the Combined Intelligence Objectives Sub-Committee we publish month to month may see beyond the bare facts given above into some of the eventual results of these penalties.

The fact that no synthetic petrol will be made means, too, the disappearance of a host of by-products ranging from special emulsifying agents to gases from which plastics were made. The end of synthetic rubber means the end of much polymer research and a diminution in polystyrene production. The end of synthetic ammonia from the air means dependence on coal-distillation ammonia and a consequent limitation, because of the general demands for it, in the production of urea resins, melamines and of nylon and similar fibres derived from nitrogen compounds, for much ammonia must be used for her great need of ammonium sulphate fertiliser.

Her large phenolic resin production will not be greatly affected except in so far as her synthetic phenol will be limited by a diminution in sulphuric acid manufacture, and we note that exports of electrical goods will be permitted. This will no doubt absorb large quantities of such resins and, of course, polystyrene and other polymers. Her large cellulose and cellulose product industries producing sheet and fibres will remain unaffected.

Much indeed has already been destroyed, for all chemical and allied factories became special targets for our bombers, and many will require rebuilding. When this takes place we shall see a complete re-orientation of German industry to the production of goods for a peaceful world.

GAUGE AND TOOL MAKERS' EXHIBITION

IT was with considerable interest that we entered the New Hall, Vincent Square, London, S.W.1, early in January, to see the opening of the first industrial exhibition in the country. Our interest was more than casual, since the secretary of the Gauge and Tool Makers' Association is our old friend Mr. Gilbert T. Beach, one-time secretary of the British Plastics Federation, and we had never seen a gathering of gauge and tool makers in full cry before. If crowds are any criterion of success, then this must have proved a very excellent show indeed, for it was most difficult to approach the stands. Visitors from all over the country were there, for no doubt it had been extremely difficult during the war to get about and find all the newest tools that were available.

Without doubt this industry shows Great Britain at its best. There is nothing to our mind so fascinating nor, if we may hazard the word, beautiful as handling a gauge or precision tool on which both genius and traditional care has been expended to make them the finest in the world.

Our own industry, especially the moulding and laminating sections of it, are indissolubly linked up with it, for, like so many other industries, gauges and measuring instruments, jigs and fixtures and special tools, press tools and moulds and dies are our life's blood; the fineness of its workmanship is reflected in our own.

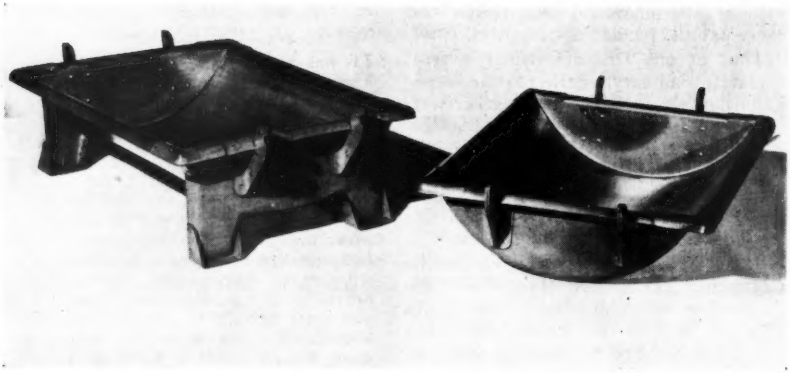
Among many familiar names in the stand-holders we noted Arnott and Harrison, Ltd., who specialize in plastic moulds, but seem also to cover a vast range in jigs, fixtures, tools, gauges and cutters. There was also on show at this stand an exhibit of plastic goods produced on the company's moulds.

B.I.P. Tools, Ltd. (the initials hide the better-known British Industrial Plastics), displayed the war efforts to fulfil the requirements of the various Ministries for plastic tools. Thermosetting mouldings and moulds were prominent, but thermoplastic exhibits were also on view, for the company is equally interested in these.

Dowding and Doll, Ltd., so well known for injection moulding plant, showed thread milling hobs made from solid tungsten high-speed steel.

Fox and Offord, Ltd., in addition to a wide range of tools and calliper gauges, exhibited a number of finished moulds, compression, injection and transfer, for the industry.

We offer our congratulations to the Association for a most revealing exhibition.



Aircraft components shaped from Bakelite laminated.

Forming Bakelite Laminated Material

This article describes methods that have been successfully adopted for the forming of Bakelite laminated material. The process has recently been brought to a successful conclusion and some of the uses to which it has already been applied are discussed.

ENGINEERS have become very familiar with phenolic laminated materials in recent years. The application of these materials to industrial processes has become so widespread that their use extends into almost every branch of engineering. For most of these applications, the material is machined by sawing, turning, punching, planing, drilling, or by any one of the accepted techniques based on earlier metal or wood practice, and which have become standard for machining these types of plastics. Efforts have been made in the past, with moderate success, to produce laminated mouldings by building up treated paper or fabric to a suitable pattern and moulding in a closed mould. Of far greater importance, however, is the successful development of a method of forming laminated material. This development has already found many industrial applications, but little more than the fringe of the ultimate potentialities has been touched upon.

The production of normal laminated sheet consists of impregnating sheets of paper or fabric with synthetic resin—usually phenolic resin for tasks requiring mechanical strength—piling the requisite number of laminations to produce a final sheet of the necessary thickness and compressing the whole into a solid board under heat and pressure. Phenolic synthetic resins are thermohardening, so that the laminated sheet as thus produced is not very sensitive to heat. Heat causes some slight softening, and if the heating is continued to a high temperature and for a long time, blistering and charring will ultimately cause the destruction of the material. It has, however, been realized for many years that, before this blistering and charring takes place, the material does, to some extent, become softer under the application of heat. A considerable quantity of laminated material is used for the production of punchings for various electrical and mechanical purposes. Some of these punchings are quite intricate and, for

some applications, a high-grade material, which usually means a high resin content material, has to be used in order to obtain sufficient water resistance. Fabricators have known for many years that this type of material can very often only be punched hot, so that, in this respect, they make use of the softening effect of heat on standard grades.

Generally speaking, laminated materials are quite different from metals in that they lack ductility. A metal sheet can be bent into a desired shape and will hold that shape, but an ordinary laminated material may very probably either break during the attempt to bend it, or else spring back after release of the bending stress. This can be made quite clear if the stress/strain curve for a typical laminated material is compared with the stress/strain curve for a metal, such as copper. In the case of the cold laminated sheet, the material stretches whilst stressed, and eventually breaks with an extension at break in the region of 2 per cent. In the case of, for example, copper, the extension which occurs before the breaking point is reached is very much greater. Clearly, therefore, metals, in general, can be drawn and bent with much greater facility than laminated sheet, and, conversely, if by some means laminated material could be caused to have a much higher extension before fracture, a point would be reached where drawing and forming could be easily carried out.

Efforts were made as far back as 1936 in the research laboratories of Bakelite, Ltd., to produce a suitable laminated material for post-forming. Some extremely interesting results were obtained, but the technicalities will not be discussed further here since they are of greater value to the plastics industry than to the engineer. It suffices to say that the production problem has now been solved, with the result that suitable Bakelite laminated sheets measuring up to 8 ft. by 4 ft. and varying from 1-64 in. to $\frac{1}{4}$ in. in thickness are now available.

Before attempting to form this laminated sheet, it is essential that it be heated to render it plastic. This can be achieved in various ways: on a hot plate, in a hot air oven, in a hot oil or glycerine bath, or by infra-red radiation. Most of the laboratory experiments have utilized the hot-plate method of heating because the majority of potential users are more likely to have available a hot plate than any of the other sources of obtainable heat. In addition, the heat transfer to material when it is placed on a hot plate is very rapid. It is found that for $\frac{1}{16}$-in. sheet it can be heated to 140 degrees C. in two minutes when the hot plate is at a temperature of 160 degrees C.

Coming now to the actual method of forming, consideration must be given to the various types of tool that may be used. Tools need not be expensive. It has been found that hardwood or Bakelite laminated tools stand up well. They

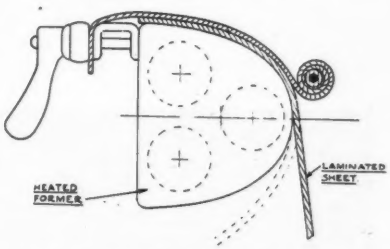


Fig. 1.—Shaping of laminated sheet on a heated former.

are light to handle, and are readily altered or replaced should they become damaged. In addition, their low heat conductivity prevents undue cooling of the sheet being formed. The simplest type of tool is that required for producing straightforward angles, and may consist of two angular-shaped pieces of hard wood. Another type of tool, more complicated, but which was used for a particular job in the past, employed a heated former over which the laminated sheet for forming was rolled progressively. (Fig. 1.) The process was slow because the heated former had to be cooled before removing the finished article. It did, however, enable some forms to be made, which were

considerably longer than could be accommodated in any existing presses.

The type of job being handled and the number of pieces to be formed very largely govern the type of tool one should use. A very simple method of making formings is that of the Guerin process which is extensively used for metal forming. In this process the tool pushes the material to be formed into a rubber or neoprene pad. The advantage of this system is that only one tool is required, but it has the defect of failing to produce the same amount of detail as is obtained in a more positive set-up. A disadvantage of the method is the gradual deterioration of the neoprene due to repeated contact with the hot sheets of laminated.

The Guerin process is rapid and, for simple shapes, specimen formings can be produced in little more than half an hour from the commencement of the process—including the making of the tool. A single tool is made and is used to press the hot Bakelite laminated sheet into the rubber. An even simpler system of tooling may be adopted when a male tool is used to press the laminated sheet through a ring of the correct form. (Fig. 2.) Hinged moulds have possibilities, and where right-angled bends with small radii are involved, very promising results have been obtained from moulds with hinged sides. For the utmost accuracy, use of a male and female forming tool is strongly recommended.

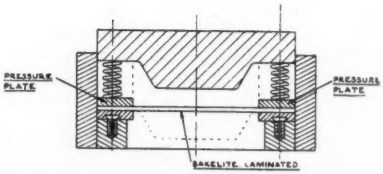
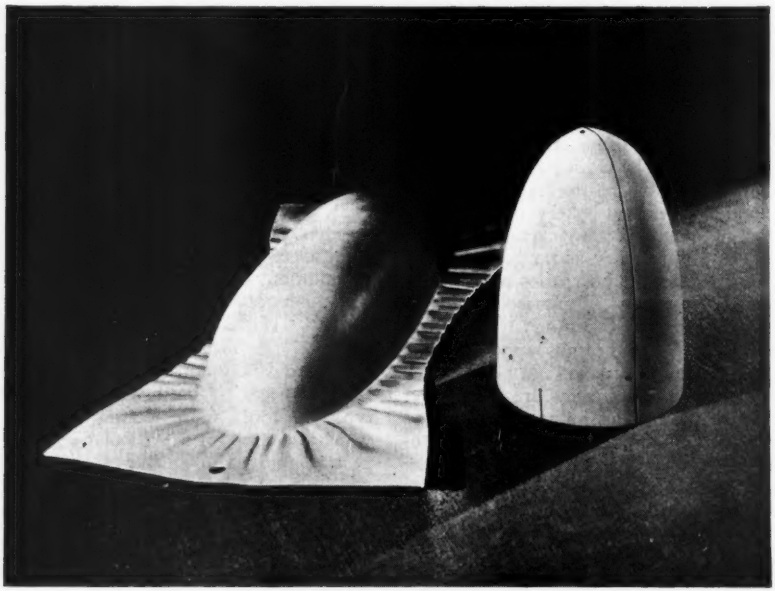
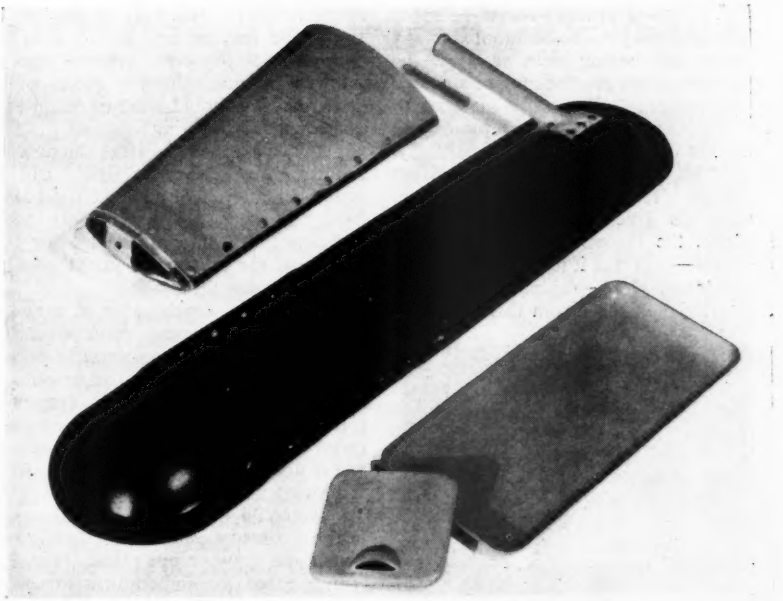


Fig. 2.—Press method of forming, using male tool and pressure plate.

In forming angles, maximum radii should be allowed wherever possible, and in all cases a radius equal to twice the



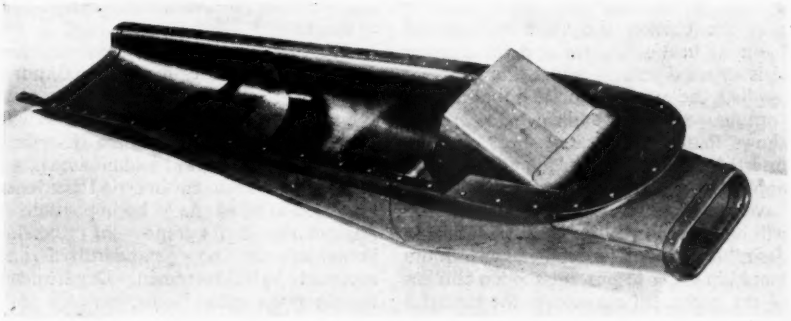
Developments of deep drawing.



The photographs on this page show a number of aircraft components made from Bakelite laminated. Shallow shapes can be readily formed with simple tools.

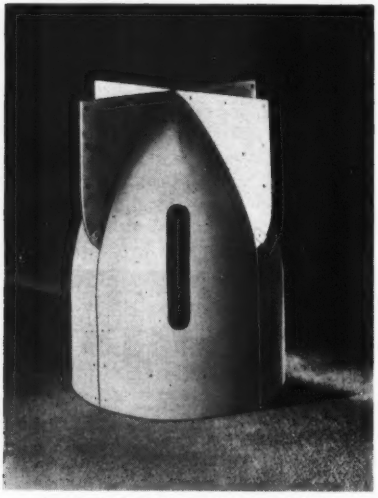
thickness of the sheet should be regarded as being the minimum which can be obtained.

Various methods may be adopted for closing the mould. For a simple bending job, toggle clamps or levers may be used, singly or in numbers. They are cheap; they are quick acting and do not take up much room. Fly presses may be used, but these usually have relatively small tables with consequent limitations in the size of article that they can accommodate. Taken all round, there is little better than the hydraulic press, especially for shapes requiring more positive pressure to impress heads and flanges, or for drawn objects having simple or double curvature.



The Forming Process

The tool and press to be adopted in any forming job having been selected, the remainder of the process may be summed up by saying: "Warm the material to 150 degrees C., place it in cool mould and close the mould quickly." Essentially, that is the method of forming laminated materials. There are, however, certain precautions which must be taken. For instance, the higher the temperature of the sheet—provided it has not reached its blister temperature—the more readily will the material form. From this it follows



Bomb fairing formed from Bakelite laminate. The complete fairing consists of four separate riveted formings.

that the quicker the sheet is removed from its heating source and the quicker it is inserted into a mould and pressure applied, the more certain is it that a good forming will be obtained. Experience shows that the preheated sheet must be inserted into the mould and pressure applied within 30 secs., otherwise it will have lost too much heat and its flexibility will have been greatly reduced. It is also desirable to have the chill taken off the mould in order to prevent sudden chilling of the preheated sheet. As the material when formed is stable at 50 degrees C., the mould may be kept at any temperature up to 50 degrees C., then it must be allowed to cool, otherwise pieces pulled from that hot mould will not retain their correct shape during cooling. More experience is required before the pressure required for a specific article can be stated definitely. For a simple right-angle bend a pressure of 4 lb. per linear inch is sufficient to form $\frac{1}{16}$-in. sheet. For $\frac{1}{8}$-in. thickness, the pressure required goes up to 50 lb./linear inch.

If a domed article with a flange is required, the pressing process is less simple. As soon as one starts to press a dome, the flange will exhibit a series of creases, and the sheet will eventually form folds. This is a trouble which metal pressers have always encountered and is due to the fact that excess material is present where it is not really wanted. To overcome this defect it is necessary to use a pressure plate as a clamping ring during the drawing operation. (Fig. 2.)

If exposed to temperatures exceeding 100 degrees C., or subjected to prolonged soaking in water, shapes formed from laminated material—in particular, right-angle bends, exhibit a tendency to revert to their original shape. It is, therefore, desirable in practice to attach the formed device so as to assist retention of the shaping. In general the characteristics of formed shapes may be stated as:—

(1) Resistance to relatively high temperatures.

(2) Cold resistance (i.e., they are not affected by freezing).

(3) Strength combined with light weight.

These properties cannot be matched by any other plastics material yet known as being formable under heat and pressure under the conditions and with the equipment which has been described. This process of forming laminated sheet after it had been finished and hardened appeared at one time to be impossible of attainment, but grades of Bakelite laminated are now standardized and accepted by Government Departments for the purpose.

PLASTICS IN THE FILM INDUSTRY

By R. N. PATERSON

TO judge by current news from the film studios, there is every indication that plastic materials, both transparent as well as opaque, are going to feature very prominently in this year's pictures and, as these films are to be shown abroad as well as in this country, British plastics will be getting something in the nature of a world-wide shop window display.

Already one film, at least, has used "Perspex" for adding a modern touch to its interior scenes. This is the film "Quiet Week-end," in which a table manufactured from "Perspex" by the studio art director, together with several lamp shades and garden ornaments, have a prominent place in several scenes. Now comes news that "Bedelia," another new British picture, will feature the first of the new plastic shoes, which at the moment are only available for export. This last example shows very clearly how British films, given, of course, the fullest co-operation between manufacturer and film producer, can be very valuable as indirect and direct publicists for British plastics.

From the film studio technician's point of view plastics of all types are going to prove very useful during the next 12 months; as it will be some time before restrictions on the supply of normal building materials for making studio sets are lifted, there will be an excellent opportunity to introduce the new materials. Plastic materials will help studio art directors to furnish their "sets," particularly those representing modern living rooms, quite as lavishly as in pre-1939 days. It can be anticipated that expert workers in plastics will be included on the staffs of most film studios, with the result that plastics will have a definite place in important British films.

This will do much to show British plastics to the overseas markets and help manufacturers to compete on even terms with American industrialists who, for some time now, have seen to it that products in plastic have been prominently displayed in American films.

Other branches of the cinema industry have been studying very closely the adaptation of plastics to the needs of post-war reconstructions, and cinema architects and decorators are more than alive to the possibilities of using plastics as aids to interior decoration and furnishing. It is proposed to use plastic materials for wall fixtures for lighting systems, and various fitments in the cloakrooms will, in many new cinemas, be of plastic. Cinema architects are planning, too, to make use of transparent material for table tops in cafés and for settees in the various waiting foyers. On the technical side a plastic cinema screen is about to be patented and a great deal of research is going on to find a suitable plastic with which to make the large film spools used in cameras and film projectors.

Recently the publicity sections of the film companies have found a new use for sheet plastic. Special lay-outs are prepared in colour and the design is silk-screened on plastic sheets, and the result is a highly satisfactory publicity display with the added advantage that it can be used again when a different design is needed. One well-known company has already used hundreds of these plastic displays for publicizing their latest picture, and intend to make this type a permanent part of all future publicity campaigns.

Apart from the use of plastics in various films the industry in general is to be the subject of several important documentary films, produced primarily for showing overseas, although some of these will also be shown to audiences in this country.

One such film has already been completed for the British Council and will be distributed by Metro-Goldwyn-Mayer. Under the title of "Plastics," and photographed in Technicolor, this film shows the manufacture of seventeen well-known plastics now in commercial use.

Electrical Plastics in U.S.A.

(Continued)

By E. E. HALLS

In the January issue the author described the thermosetting resins and the cellulose derivatives. Here he continues with the remainder of the thermoplastic materials.

(2) Vinyl Resins.—These resins are theoretically derivatives of vinyl alcohol, and from this material itself a plastic material can be derived having unusual and remarkable properties. The typical members of the group are vinyl chloride and vinyl acetate.

(A) Vinyl Chloride.[21] — Monomeric vinyl chloride is a limpid liquid of boiling point − 15 degrees C. It is converted to a fluffy white polymer under suitable conditions of heat and pressure in the presence of catalysts. The solid can be moulded under heat and pressure to give rigid sheets of horny nature, low moisture absorption, inertness to various chemical solvents and resistance to flame. For many applications this material is too hard and becomes brittle at high temperatures. With suitable plasticizers the material can be transformed to an elastic material, the properties of which depend upon the quantity and nature of the plasticizers used. It is possible by correct choice of ingredients to obtain products having flexibility at sub-zero temperatures and yet of satisfactory characteristics at high temperatures. The electrical properties depend upon the chemical nature of the plasticizer employed and, because the best plasticizers are esters having high dipole moments, the electrical properties are very sensitive to temperature and frequency changes. Average values for different materials are given in Table 17.

Plasticized polyvinyl chlorides are widely used as primary insulation for low frequency application, such as drop wire, twisted telephone wire and cable jacketing. They are not generally used in high-frequency circuits because of high dielectric constant, high power factor and dependence of these properties on temperature and frequency.

(B)—Copolymers of Vinyl Chloride and Vinyl Acetate.—By the introduction of relatively small quantities of vinyl acetate into the polyvinyl chloride chain, a copolymer is obtained of which the properties are distinctly different from those of the chloride or of the acetate. The copolymer can be made into rigid plastic shapes or by plasticization into elastomers. The rigid materials are characterized by strength, resistance to chemicals, non-inflammability and dimensional stability as well as resistance to moisture.

Table 17.—Vinyl Chloride—Average Values.

Test	Flame resistant grade	High insul. resistance grade	Cold resistant grade
Specific gravity	1.37	1.34	1.39
Tensile strength, psi	2,500	2,300	2,500
Modulus of elasticity, psi	1,100	1,100	1,400
Water absorption after 24-hour immersion, %	1.35	0.40	0.30
Elongation, %	300	350	325
Dielectric strength, v/mil.	350 to 800	400 to 850	325
Volume resistivity, ohms-cm.	10^{11} to 10^{13}	10^{13} to 10^{15}	10^{8} to 10^{11}
Dielectric constant:			
60 cycles	6.4	6.2	—
1,000 cycles	4.2	4.9	—
Power factor:			
60 cycles	0.15	0.097	—
1,000 cycles	0.115	0.109	—

Table 18.—Copolymers of Vinyl Chloride and Vinyl Acetate, Average Properties of Rigid Materials.

Modulus of elasticity	35 to 41 × 10^{14}
Coefficient of thermal expansion	6.9 × 10^{-5}
Rockwell hardness	M60 to M80
Specific gravity	1.30 to 1.45
Heat distortion point, °F.	140 to 150
Water absorption after 24-hour immersion, %	0.05 to 0.15
Dielectric strength, v/mil	400
Volume resistivity, ohms-cm.	>10^{14}
Dielectric constant:	
60 cycles	3.26
1,000 cycles	3.21
1 megacycle	3.08
Power factor:	
60 cycles	0.008
1,000 cycles	0.031
1 megacycle	0.014

As in the vinyl chloride type materials, the electrical properties are very temperature and frequency dependent.

Their chief disadvantage is low melting point. This can be seen from the information in Table 18.

With suitable compounding ingredients tough elastomers are obtained, these being suitable for primary insulation and for the protective outer jacket of cables. Table 19 shows the average values of such materials.

(C)—Polyvinyl Acetate.—Liquid vinyl acetate is a mobile colourless liquid, boiling point 73 degrees C. It is obtained by the reaction of acetylene and acetic acid in the presence of a catalyst. It polymerizes at 100 degrees C. to a colourless resinous material.

Table 19.—Copolymers of Vinyl Chloride and Vinyl Acetate, Average Values of Elastomeric Materials for Primary Insulation, etc.

Test	Primary insulation	Low temperature type	General jacket type
Tensile strength, psi	3,000	1,700	2,200
Specific gravity	1.32	1.22	1.24
Elongation, %	200	250	250
Low temperature brittleness	−17°C.	−46°C.	−38°C.
Dielectric strength, v/mil.	300	300	300
D.C. resistivity	6.2 × 10^{6}	5.1 × 10^{4}	1.34 × 10^{6}
Dielectric constant:			
60 cycles	6.0	7.4	7.6
1,000 cycles	4.8	6.7	6.9
Power factor:			
60 cycles	0.105	0.064	0.060
1,000 cycles	0.120	0.067	0.098

Here again the electrical properties of the materials depend very largely on the temperature and frequency at which measurements are made.

Catalysts such as oxygen or peroxides accelerate the reaction.

Polyvinyl acetate was suggested as a suitable base for lacquers and coating materials. However, interest in it has diminished because of the low softening point of polyvinyl acetate and the development of newer synthetic plastics which have superior electrical and physical properties. Its use is, therefore, largely confined to adhesive leather finishing in the lacquer field.

(D)—Polyvinyl Alcohol. — Water soluble polyvinyl alcohol is formed by the hydrolysis of polyvinyl acetate. The alcohol itself has not been isolated, and the polymer can only be formed by this roundabout method. It is a remarkable material which is used to some extent in the manufacture of hose and tubing for the conveyance of oils and greases and other organic solvents. It is not very interesting for electrical applications because it is hydroscopic.

Table 20.—Formex.

Tensile strength, lb. per sq. in.	9,000 to 12,000
Coefficient of thermal expansion	7.7 × 10^{-5}
Modulus of elasticity	26 to 10^{5}
Rockwell hardness	M80 to M90
Elongation, %	4 to 11
Specific gravity	1.2 to 1.3
Heat distortion point, °F.	160 to 170
Water absorption after 24-hour immersion, %	0.6 to 1.3
Dielectric strength, v/m. (In very thin films, may be as high as 1,600 v/m.)	300 to 600
Dielectric constant:	
60 cycles	3.6 to 3.7
1,000 cycles	3.3
1 megacycle	3.0
Power factor:	
60 cycles	0.007
1,000 cycles	0.01
1 megacycle	0.02

(E)—Polyvinyl Acetals.—These are a series of resins which have wide application and they are formed from the acetate by suitable chemical treatment. The polyvinyl butyrals suitably plasticized form tough impact-resistant, adhesive interlayer materials, for which the principal application is for safety glass. Their electrical properties are not very good.

Polyvinyl formal has interesting properties and is being used as an insulating material for electrical wires. Moisture

resistance, solvent resistance, temperature stability, abrasion resistance, flexibility, toughness and dielectric strength in very thin films has led to its adoption as a superior insulating enamel on fine instrument wires. Its properties are covered in Table 20 by the material " formex."

(3)—Polyvinylidene Chloride.—This is one of the newest of the group, and it is a non-inflammable, dimensionally stable material with good mechanical properties. Electrically it is not very good, and its chief applications are for plastic tubing where a wide variety of chemicals can be handled safely. It is also being developed as a textile fibre because of its unusually high tensile strength in oriented films. Properties of the material are given in Table 21.

Table 21.—Polyvinylidene Chloride.

Impact strength, ft. lb. per in.	2 to 8
Tensile strength unoriented, psi	4,000 to 7,000
Coefficient of thermal expansion	15.8×10^{-5}
Elongation, %	10 to 40
Rockwell hardness	M50 to M65
Heat distortion point, °F.	150 to 180
Specific gravity	1.68 to 1.75
Dielectric strength $\frac{1}{8}$ in. short time, v/m	400
Volume resistivity, ohms-cm.	10^{14} to 10^{16}
Dielectric constant:	
60 cycles	3 to 5
1,000 cycles	3 to 5
1 megacycle	3 to 5
Power factor:	
60 cycles	0.03 to 0.08
1,000 cycles	0.03 to 0.15
1 megacycle	0.03 to 0.05

(4)—Acrylic Esters.[22, 23, 24, 25] — The most widely used member of this group is methyl methacrylate. It is available as a moulding powder in a wide range of colours, as well as in cast sheets. Its major applications are where a transparent material having good light transmission properties is required. It is not outstanding electrically and its properties are shown in Table 22. It is unsuitable where high frequencies are concerned and where power loss must be minimized, but in these respects it is superior to the thermosetting plastics.

(5) Nylon.[26]—The so-called nylons are polyamides. They have been chiefly employed in the form of yarns and fabrics because of their fibre-forming characteristics. With the recent introduction of nylon FM-1, as an injection moulding powder, even wider applications are indicated.

Table 22.—Methyl Methacrylate Polymers, Average Properties.

Tensile strength, psi	7,000
Modulus of elasticity in tension, psi	$3 \text{ to } 5 \times 10^{-5}$
Rockwell hardness	M70 to M90
Specific gravity	1.18 to 1.20
Coefficient of thermal expansion, °C.	$7 \text{ to } 9 \times 10^{-5}$
Elongation, %	1
Heat distortion point, °F.	125 to 165
Water absorption after 24-hour immersion, %	0.2 to 0.3
Dielectric strength, $\frac{1}{8}$", short time, v/m	500
Volume resistivity, ohms-cm.	$>10^{15}$
Dielectric constant:	
60 cycles	3.6
1,000 cycles	3.0
1 megacycle	2.8
Power factor:	
60 cycles	0.05 to 0.07
1,000 cycles	0.05 to 0.07
1 megacycle	0.02 to 0.03
Arc resistance	Good

Filaments of nylon are prepared by spinning the molten polyamide through special spinnerets and then cold-drawing the resultant thread. In this process the long chain molecules become oriented with resultant high tensile strengths.

Nylon, like polyethylene, has a sharp melting point, and just above the melting point the material is very fluid. For moulding, therefore, careful design of injection nozzles is necessary.

The nylons so far produced are not very good electrically when compared with the hydrocarbon plastics, but high-softening point makes them very attractive when electrical properties are not critical. The properties of the material are illustrated

Table 23.—Nylon.

Test	General purpose	FM-1
Impact strength, ft./lb. per in.	2.18 to 4.25	9.4
Tensile strength, psi	9,000	10,500
Modulus of elasticity in tension, psi	3.25×10^{-5}	3.25×10^{5}
Specific gravity	1.14	1.14
Coefficient of linear expansion per °C.	10.3×10^{-5}	5.7×10^{-5}
Melting point, °C.	263	—
Elongation, %	83	54
Dielectric strength, v/m	380 to 400	400
Volume resistivity, ohms-cm.	10^{13}	10^{13}
Dielectric constant:		
60 cycles	3.8 to 7.0	3.8
1,000 cycles	4.0 to 20	4.0
Power factor:		
60 cycles	0.018 to 0.13	0.018
1,000 cycles	0.05 to 0.11	0.05

for a general-purpose nylon and a special FM-1 injection moulding material in Table 23.

6. Polyvinyl Carbazole. Originally this material was developed in Germany and more recently made in America. The material is brittle, but has high resistance to deformation by heat and good electrical properties and, therefore, it has been used as a substitute for mica in radio frequency blocking and by-pass condensers. It can be used on high-frequency and D.C. operation. Little information is available upon its properties. In condensers the D.C. breakdown on one grade is of the order of 3,000 v. per mil. on a sheet 2 mils. in thickness. The dielectric constant is about 5.5 and power factor at 1 megacycle is 0.016. Power factor decreases as temperature increases, as would be expected from a material of this type. The material can be operated at 125 degrees C. without adverse effect.

Polyvinyl carbazole is resistant to aliphatic hydrocarbons, alcohols and ethers, but soluble in aromatic hydrocarbons, such as benzene, and chlorinated hydrocarbons, such as chlorobenzene. Its use, however, is limited by the brittle nature of the plastic and somewhat difficult processing.

7. Hydrocarbon Plastics. The hydrocarbon materials are probably the most important from the electrical standpoint. In nature they are essentially non-polar and, therefore, they possess low dielectric constants and good power factors over a wide range of temperatures and frequencies. Up-to-date polythylene, polystyrene and polybutene have been the most important.

A. Polyethylene.[27] During the nineteenth century it was discovered that ethylene gas could be polymerized by heat in the presence of metallic chlorides and paraffinic oils, and other materials resulted. In 1935 a method was found for producing a solid polymer. The gas was heated at pressures above 1,000 atmospheres and temperatures up to 400 degrees C. with a carefully controlled amount of oxygen. A tough, waxy, solid polymer having a relative sharp melting point at about 150 degrees C. was obtained. The material became available in America in 1941, and considerable quantities are now produced.

Polythene has the lowest dielectric constant of any commercially available plastic, and a correspondingly low power factor. It possesses a wide temperature range of usefulness and a low specific gravity. At present the major outlet is for primary insulation of high and ultra-high frequency transmission lines. Its disadvantages are flamability, somewhat sharp melting as contrasted to the gradual softening of most thermoplastics, high coefficient of expansion and tendency to become contaminated electrically when brought in contact with materials of poorer electrical properties. Being a hydrocarbon analogous to paraffin wax, it suffers oxidation when heated in air. This oxidation is accompanied by an increase in power factor and, therefore, one practice is to add a small percentage of anti-oxidant to the material to offset this drawback. Average properties are given in Table 24.

Table 24.—Polyethylene, Average Properties

Tensile strength, psi	1,700
Coefficient of thermal expansion	10.5×10^{-5}
Rockwell hardness	R13
Specific gravity	.92
Elongation, %	500
Heat distortion point, °F.	140
Water absorption after 24-hour immersion, %	0.01
Dielectric strength, v/m 3 to 15 mils thick	1,000 to 1,500
Volume resistivity, ohms-cm.	10^{17}
Dielectric constant:	
60 cycles	2.22 to 2.26
1,000 cycles	2.22 to 2.26
1 megacycle	2.22 to 2.26
1,000 megacycles	2.22 to 2.26
3,000 megacycles	2.22 to 2.26
Power factor:	
60 cycles	.0002
1,000 cycles	.0002
1 megacycle	.0002
1,000 megacycles	.0002 to .0004
3,000 megacycles	.0003 to .0005

B. Polystyrene. This is probably the oldest synthetic organic plastic, discovered in 1839 by Simon.[28] Its formation from monomeric styrene has been previously described (1). Polystyrene has low specific gravity, excellent dimensional stability, outstanding electrical properties and remarkably low moisture absorption.

Table 25.—Polystyrene—Physical Properties of a Typical Commercial Material.

Tensile strength, psi	5,500 to 7,000
Coefficient of thermal expansion	6 to 8 $\times 10^{-5}$
Modulus of elasticity in flexure, psi	4.0 to 4.7 $\times 10^{5}$
Specific gravity	1.05
Heat distortion point, °F.	165 to 190
Water absorption after 24-hour immersion, %	0.00
Elongation, %	2 to 3
Rockwell hardness	M80 to M90
Dielectric strength, ⅛", short time	500 to 700 v/m
Arc resistance	120 to 135 seconds

Because of the chemical nature of the plastic, whereby depolymerization occurs when the arc takes place, the material will withstand repeated arcing without substantial lowering of its arc resistance. The surface and volume resistivity of polystyrene are so high that it is difficult to obtain accurate measurements, but values for the surface resistivity are greater than 10^{16} ohms-cm., while its volume resistivity is 10^{17} to 10^{19} ohms-cm.

DIELECTRIC CONSTANT

The following values for the dielectric constant have been obtained at room temperature:

60 cycles	2.55
1,000 cycles	2.55
50,000 cycles	2.53
1 megacycle	2.53
20 megacycles	2.52

Measured at 60 cycles, with a potential gradient of 50 volts per mil, the dielectric constant with increasing temperatures is shown below:

Temperature, °C.	Dielectric constant
30	2.55
60	2.57
90	2.60

POWER FACTOR

60 cycles	0.0002
1,000 cycles	0.00015
40,000 cycles	0.00022
1 megacycle	0.00016
20 megacycles	0.00028
1,000 megacycles	0.00028

It can be readily fabricated by normal methods. Properties of a typical commercial material are given in Table 25. Limiting properties are relatively low softening point of 165 to 190 degrees F. and rigidity at ordinary temperatures. Work has been done towards improving the heat resistance of polystyrene, and the more important is the formation of "cross links" polystyrene by adding small amounts of paradivinyl benzene to the styrene before polymerization (29). A cross-linked polystyrene produced in this manner is infusible and insoluble in solvents and it becomes rubbery on heating, but retains its shape to a remarkable degree. This reaction is thermosetting in nature and, therefore, only cast forms of the material can be prepared. Subsequent fabrication by machining to size or shape is necessary. Crotonates and Allyl derivatives have also been suggested as cross-linking agents. Commercially a styrene rod of this type is marketed by the G.E.C. under their code No. 1421.

The Monsanto Chemical Co. developed heat-resistant polystyrene, known as styramic, by a different approach. They incorporated chlorinated diphenyl in the polystyrene itself. This procedure has the advantage of conferring some degree of flame resistance to the material. The electrical properties are satisfactory for some applications, but not so good as those of pure polystyrene. Dielectric constant is somewhat higher, being 2.8 and 3.0. An even more recent development is the manufacture of polydichlorostyrenes having higher softening points and electrical properties comparable with those of pure polystyrene. No details of these materials are yet available.

To secure greater flexibility, the Dow Chemical Co. investigated copolymers of styrene with other materials. One product marketed is styraloy, which has remarkable flexibility even at low temperatures and is reasonably resistant to heat. Further, it has excellent abrasion resistance and good resistance to organic solvents and oils. Electrical characteristics are reasonably good at low frequencies, but an anomalous dispersion above 1 megacycle is observed, where the power factor attains quite high values. It is, therefore, unsuitable for ultra-high frequency work. At present styraloy has its major application to primary insulation of ignition wiring. Properties of the material are given in Table 26.

Table 26.—Styraloy.

Tensile strenth, psi	1,000
Specific gravity	0.957
Heat distortion, °F.	150
Water absorption after 24-hour immersion, %	0.2
Elongation, %	200 to 250
Dielectric strength ⅛ in., short time, v/m	700
Volume resistivity, ohms-cm.	10^{20}
Dielectric constant:	
1,000 cycles	2.5 to 2.6
1 megacycle	2.6 to 2.7
50 megacycles	2.5
Power factor:	
1,000 cycles	0.0007 to 0.0012
1 megacycle	0.0005 to 0.0010
50 megacycles	0.0035 to 0.0040
100 megacycles	0.0040 to 0.0050

Table 27.—Polybutene.

Tensile strength, psi	500
Elongation, %	550
Low temperature flexibility	Not brittle at -78°C.
Heat distortion point	Below room temperature
Power factor:	
60 cycles	0.0003 to 0.0005
1,000 cycles	0.0003 to 0.0005
1 megacycle	0.0003 to 0.0005
10 megacycles	0.0004 to 0.0006
100 megacycles	0.0004 to 0.0006
Dielectric constant:	
60 cycles	2.25 to 2.35
1,000 cycles	2.25 to 2.35
1 megacycle	2.25 to 2.35
10 megacycles	2.25 to 2.35
100 megacycles	2.25 to 2.35

C. Polybutene. Isobutylene gas treated with a catalyst such as boron trifluoride at low temperatures around −80 degrees C. is polymerized to a very rubbery material known as polybutene, vistanex, or oppanol. The extra molecular weight and physical properties of the polymer are dependent upon the temperature of polymerization and, consequently, products ranging from soft, sticky liquid to very tough rubber can be procured. The material is resistant to strong chemicals and ozone, and electrical properties are excellent. Cold flow prevents the material being used by itself, but it is useful for compounding with other materials to improve their properties. Thus, it is used to improve viscosity of lubricating oils and high-melting point adhesives when mixed with paraffin wax. Low-temperature flexibility is outstanding. On account of the variable nature of the properties depending upon molecular weight, it is difficult to present physical properties, but Table 27 gives the characteristics that can be expected from a material having a molecular weight of approximately 100,000.

Conclusion

For highest electrical performance where dielectric properties are of paramount importance the pure hydrocarbons, such as pure polystyrene and polythene, are the best materials available. It is difficult to envisage at this stage any marked improvements in this direction, but rather that developments will be towards combining these properties in materials developed to improve upon their mechanical performance or other physical properties.

A comprehensive list of references is given, covering test methods, and researches and patents not dealt with in detail in the foregoing.

Two of the plastics already referred to here, namely, the melamines and the nylons, are regarded from this side with more than interest. Detailed information will be given on these, from American sources, later. Further, at a future date, it is hoped to give a survey of electrical plastics in this country in comparison with Warner's account, dealing only briefly with the better-known materials, but in more detail with those concerning which less practical information has been published. As far as possible, it will be given under the same system of classification and sub-headings.

[Note.—The silicone resins are of such importance that a special article dealing with them will be published in our next issue.]

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Old Copies of "Plastics"

We are trying to build up an efficient library and reading-room to meet the varied demands of the Regiment this winter.

The promise of severe weather and the birth of the Army Educational Scheme have thrown a burden on our limited resources, which we are at the moment quite unable to bear. If, then, you know of a reader who would be kind enough to forward to us his used copy of your periodical, we would be grateful. We could assure him it would be warmly appreciated and widely read.

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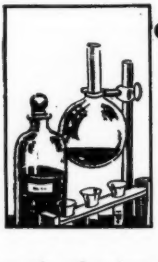
World's Industry Employs Plastics

GENERAL ENGINEERING

Wear resistance of die material for plastic moulding may be evaluated by the use of a newly developed wear tester which in 1½ hours and with the use of about 2 litres of moulding powder will give a practical working figure. (Mehdornm "Kunststoffe," 1944/34/133.) **Testing of plastics at low temperatures** forms subject of a new two-page VDI data sheet issued in October, 1944 (VDI Verlag, VDI 2025.) Survey of German technical work during 1944 on standardization testing design and general recommendations for plastics technology has been given by Ude in VDI Zeitschrift, 1945/89/4. **Impregnation of plaster of Paris** forms and patterns with synthetic resin gives every indication of providing a technique which will influence considerably the task of meeting tooling requirements in the sheet metal working industries. An account is presented by Delmonte in "Automotive and Aviation Industries," 1945/93/32. **Centrifugal casting** presents a major problem in the knocking out of the pattern without dislodging the sand. In a new design the sand mix is contained in a heavy sheet-metal cylinder, the wooden pattern being replaced by one of polystyrene, which, when the work is completed, is moulded up by induction heating. Heat is applied slowly in four one-minute cycles separated by one-minute intervals. "Scientific American," 1945/173/351. Survey of the immense number of **machine parts composed mainly of synthetic rubber,** but sometimes of natural rubber, which are in use to-day is given in "Machine Design," 1945/17/116. The compilation of the survey is the result of the co-operative effort of eight American rubber concerns. **Riveting anvils** fitted with rubber inserts and made of aluminium show greatly reduced fatigue loss and shock effect due to the light weight and high damping capacity of the system; "riveter's palsy" is very largely eliminated by this practice. "The Machinist," 1946/89/2259. **Production of, moulding and extruding of "Silastic,"** the silicone rubber-like plastic developed by the Dow Corning Corp. of Michigan, is dealt with in an illustrated article in "Machinery Lloyd," 1946/18/87. Laminated material and coating stock are also dealt with.

CHEMICAL



Kriston, a new product of the Goodrich Chemical Co., is described as a non-flammable thermo-setting plastic. Its exact nature is not revealed but it is merely described as a result of polymerizing a liquid monoer in the presence of a suitable catalyst. Good resistance to abrasion is claimed together with high inertness to chemical attack. ("Machine Design" 1945/17/175.) **Pipe connectors in P.V.C.** were subjected to tensile bursting and bending tests by Hennig reported in "Kunststoffe" 1944/34/161. The author shows that advances in workmanship, as well as physical and chemical non-uniformity of the pipe material are of more importance in safeguarding against failure than design of the connection itself. Connections made with adhesives require 24 hours' setting

at least before use, whereas welded connections may be used immediately. Furthermore, the chemical resistance of the welded connection is very high. Use of modern **plastics in the chemical laboratory** is briefly reviewed in "The Laboratory," 1945/15/103. Better laboratory paint has been developed by Fisher Scientific Co. Test based on a cyclocized derivative of a special synthetic rubber and contains about 98 per cent. hydrocarbon. Known as "Plicote," the paint has many properties which might be associated with the polymerized rubber constituting its main bulk. It is very resistant to attack by acids and alkalis. "The Laboratory," 1945/15/119.

BUILDING

Experiences with straight sawed-faced lumber glued-laminated wooden arch construction in war emergency buildings of the U.S. Coast Guard Academy, New London, Conn., has been compiled by Dubin. It was found that well-sawed laminations for glued faces will provide joints of neat appearance and adequate strength if proper glueing and fabricating methods are used. Machining of surfaces to be glued should be practised only to obtain uniform thickness of laminations, or to remove any rough or excessively torn grain. "Mechanical Engineering" 1945/67/813. **Future home in plastics** forms subject of an illustrated account in the plastics section of "Scientific American" 1945/173/338. Plastics, it is claimed, will provide the modern small home with transparent, dirt-resistant, easily-cleaned walls and provide the illustration of comfortable size to small rooms. **Single-type flexible cord** with a plastic jacket has hitherto been the only form approved on household appliances by the Underwriters Laboratories, U.S.A. P.V.C. has been used as the insulator. "Scientific American" 1945/173/375.

MISCELLANEOUS

Test packages containing plastic bottles and glass bottles of similar form were recently made the subject of a comparative examination. Acetate bottles showed greatest endurance, whilst butyrate stood up to shock nearly as well. The problems of polystyrene varied widely but glass breakage was the highest. "Scientific American" 1945/173/340. **"Silastic,"** a silicone resin of rubberlike properties and produced in various stocks for moulding, extruding, coating and laminating, has now been released for commercial and civilian use. "The Machinist" 1945/89/2156. **Production, machining and properties of plastics** form the subject of a well illustrated general account by Eilbensteiner in "Fertingungstechnik" 1944/2/165. The account refers mainly to German literature on the subject. In the same journal, on page 154, is discussed the problem of the hobbing process for making satisfactory but inexpensive dies for thermosetting plastics. This useful and complete account is by Doffine. **Method for preventing ejector-pin marks** on compression moulded plastic parts has been devised by Wessel and is described in "The Machinist," 1945/89/2035. Unnecessry depreciation of power in generation of ultrasonic vibration led to the idea of concentrating the "waves" by means of solid lenses. It was found that concave lenses of polystyrene transmit about 88 per cent. of the incident energy, whilst polymethylmethacrylate lenses give a transmission of 89.9 per cent. (Ernst. "Journ. Scientific Instruments," Vol. 22, p. 238.) **Resin-impregnated glass cloth laminates** were developed as body armour for the Services; the laminates were in the form of a thin rigid sheet and were designed to stop penetration of steel fragments. The armour has been used successfully in the Air Force.

G

The Microscopic Examination of Plastic Materials

VI.—Mouldings: (a) Fillers (Wood Flour)

By J. H. WREDDEN, F.R.M.S.
(Chief Chemist, Igranic Electric Co., Ltd.)

The examination of the function played by fillers in moulded resins is a most complicated one, and any information which can be collected on this subject is of value. The author, as in past issues, deals mainly with the matter employing the methods of microscopy. In this first portion dealing with wood flour we have asked him to give readers an insight of the histology of wood in order that, beginning at the beginning, we may obtain a better insight of one of the most important of our raw materials. We therefore make no apology for this section.

HAVING dealt with laminated materials, let us now turn our attention to moulded products and see what the microscope can tell us about these materials, around which there has been so much controversy.

By moulded materials is meant those whose fabrication depends upon the use of a powder made from a thermosetting resin, into which is mixed some substance which acts as a filling agent.

As the properties of the finished moulding depend almost entirely on the nature of the filling materials, it behoves us to examine these latter in some detail. The number of substances capable of use as a filler is almost limitless, but in practice only a few are used, mainly to impart mechanical or electrical strength to the finished article, although there are cases where a lesser-known material is used with the object of imparting some specific property.

Therefore, we must bear in mind that these substances are in no sense to be regarded as adulterants to resin; rather should they be looked upon as a component part of the moulding, complementary to the resin, so that the absence of either would prevent the production of the desired result, although, at the same time, it should be remembered that it is a simple matter to lower the cost of any given moulding by increasing the proportion of filler in the powder.

Thus it is obvious that for the consistent reproduction of any desired combination of properties in any given moulding, much thought is required in the careful selection of the filler and the proportion in which it is to be incorporated in the moulding powder.

Filling materials may be broadly classified under two main headings, viz.:—(1) Organic, which includes such substances as wood, straw, cotton, etc., and also some of the synthetic fibres. (2) Inorganic, such as slate, mica, silica and the like. Of all these materials, wood flour is probably the most widely used and has been in use for a great many years; in fact, it was, in all probability, the original material used for this purpose. Wood flour is relatively easy to produce at a low cost, and, if correctly chosen as to grade and quantity, is capable of ensuring the production of mouldings with good electrical and mechanical properties, but this does not mean to say that there is no further room for improvement, for it is the author's opinion that this material has been used far too long, with too little being known about it. This is more particularly applicable to the basic material from which the wood flour is obtained, viz., "wood." This does not mean to say that nobody knows anything about wood, but rather to imply that the vast amount of knowledge about this material that has so

far been accumulated by botanists and the like does not appear to have been used to any great extent in its application to the production of plastic materials. If it has been so used, then the paucity of published information is to be regretted.

Therefore, it is proposed to deal with the subject of wood flour first and in some detail. So let us commence by examining the structure of wood, or, in other words, indulge in a brief study of the histology of wood, which deals with its microscopic structure. This is very

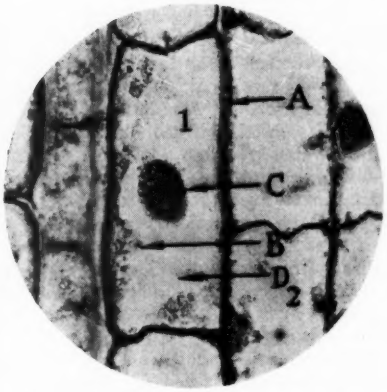


Fig. 53.—Section of growing root tip showing typical basic plant cell. Mag. 700 diameters.

necessary if we are to obtain any information on the nature of the material we intend to use, as it is used in the form of microscopic particles broken down from the parent material, and when it is considered that the wood itself is made up of microscopic " bricks," as it were, the need for a histological survey of the basic material becomes apparent.

Wood is usually obtained from the class of vegetation known as seed or flowering plants. The whole structure is built up of small units or cells. The process of structure building may be described as follows:—In the first instance two germinating cells fuse to form one cell, which may be termed the " foundation stone." This cell multiplies by simple division into two new cells, which, in turn, multiply similarly. Thus we have a process of development from a single microscopic body to the fully grown tree. During this process of multiplication, and as the plant grows, certain cells become modified in structure in order that they may carry out specific duties. In some cases the modification demanded is very considerable, while in others there is scarcely any alteration from the structure of the basic cell. A single plant cell may be seen in Fig. 53, which is a photomicrograph of a portion of a section from the growing tip of an onion root at a magnification of 700 diameters. We may take the cell marked (1) as a typical example of the basic plant cell from which all others are derived; its structure is typical of all plant cells and may be seen to consist of a cell wall (A) composed mainly of cellulose, which completely encloses the contents consisting of the protoplasmic lining (B), embedded in which is another protoplasmic body (C), the nucleus. (It will be seen that in this instance the nucleus has become detached from the lining protoplasm and lies somewhat towards the centre of the cell. This is actually an artificial condition produced in the sectioning. The nucleus in the cell marked (2) will, however, illustrate the point.) This body is the living heart of the cell and controls the metabolic functions which result in development and reproduction; when the nucleus dies the cell dies and the contents degenerate, leaving the wall only. The large space (D) in the centre, which, in early life, is completely filled with protoplasm, contains the fluid known as cell-sap. This space is known as the vacuole.

So much then for our basic brick from which eventually the wood is derived. In the early stages of the development of the plant, the cells are all living, but as the plant gets older and increases in size, the need for mechanical support becomes apparent, as also does the necessity of a more efficient means whereby water and nutrient fluids may be transported about the whole body. This results in certain

Fig. 54.—Longitudinal section through sieve tubes, showing general structure. Mag. 700 diameters.

cells becoming structurally modified to carry out the necessary functions. The regions in which numbers of these cells suffer similar modifications are collectively known as tissues, thus the entire tree is built up of a number of tissues, each having its more or less specific function.

As we are only concerned with the woody tissues obtained from the stem, we will confine our examination to that structure and the tissues found in it. Here, again, some of the tissues will not be dealt with in great detail, as, so far as we are concerned, they are only of a secondary nature.

We have seen that the stem is composed of a number of tissues, therefore, before studying the general structure, let us examine the tissue elements, after which we will be in a position to see where and how they fit into the general scheme of things. Perhaps the most important tissue, so far as the plant is concerned, is that known as parenchyma. This is a basic ground tissue made up of living basic cells, found interpenetrating all the other more specialized tissues of the plant, and it is by means of this tissue that nutrient substances are distributed through the general structure. Parenchymatous cells are modified in certain regions where their work becomes somewhat more specialized. Thus we have the next tissue, known as the cambium. This is a very thin layer of cells responsible for the growth of the whole plant and is composed of parenchymatous cells which are, however, highly active and are responsible on the one hand for the development of the actual wood, and on the other for the bark or living portion of the tree.

The next important tissue found on the bark side of the cambium is known as the phloem. This consists of cells which have been considerably modified in order to perform a specialized function. They are known as sieve tubes, two of which are illustrated in the longitudinal section in the photomicrograph at Fig. 54, at a magnification of 700 diameters. They will be seen to consist of the usual cellulosic wall (A) within which the contents will be seen to have degenerated to what appears to be a slimy strand (B) (this is apparently of proteid nature) formed by an apparent shrinking away of the protoplasm from the wall. The end walls of the cells (C) became modified to the extent that they are perforated (this magnification is not sufficiently high to show this), thought to be brought about by the action of an enzyme secreted for the purpose. Thus it will be seen that by means of the perforated end walls (sieve plates) each

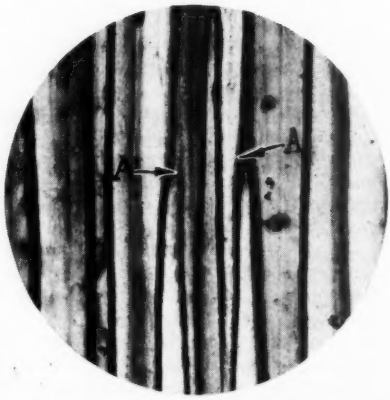


Fig. 55.—Longitudinal section of bast fibres. Mag. 700 diameters.

cell is in communication with the one immediately above and below. In this way the sieve tube is developed and the slime strand becomes continuous along its length.

During the early life of the cell the vacuole becomes filled with a highly nitrogenous nutrient fluid and the nucleus disappears. Therefore, the sieve tube may be considered as dead, but as each tube has attached to it one or more living cells known as companion cells, which are thought to control the activity of the phloem as a whole, this latter tissue may be considered as a living tissue.

In many instances, after the cell has reached its full growth, the cell contents commence activity in a different direction, resulting in structural modifications to the cell wall, which usually takes the form of thickening, which takes place by the deposition of lignin, which, when complete, sees the death of the cell. Tissues derived from this process are those which go to make up the strengthening parts or skeleton of the tree, and, so far as we are concerned, are the most important.

This thickening varies in form and may be so great as to almost obliterate the cell cavity. Heavy thickening of a uniform character is found in the regions of bast fibres in the bark portion, in which the cell walls are much thickened. Some bast fibres are illustrated in Fig. 55 at 700 diameters, from which it will be seen that the cells are very long in relation to their diameter and have long tapering ends which fit into one another as seen at (A). Thus it will be seen that a strong elastic structure will be produced and as they occur in bundles throughout the bark their function as strengthening members will be appreciated.

Whereas there are other tissues present in the bark, it is not proposed to deal with them individually, but the phloem, consisting, as it does, of sieve tube and bast fibres, has been described in some detail owing to the possibility of these tissue elements being used as filling material. Thus, if we bear in mind that all the tissues on the bark side of the cambium form the living and active part of the tree and leave it at that, our examination of the general structure will not include unnecessary detail.

Having studied the structure of the two tissues in the bark which show any promise of being useful, suppose we now direct our attention to those which go to make up the actual woody portion of the tree. As has been stated, this section is laid down by being cut off on the inside of the cambium and in the main consists of closely packed tubes embedded in a mass of parenchymatous material, which usually degenerates into the pith in those plants rich in this substance; although it must be remembered that in those cases where there is no pithy mass in the centre of the stem this is distributed throughout the wood structure in general.

The wood itself is composed of dead cells possessing lignified walls, which may be classified under two main headings, viz., Trachieds and Vessels. In all cases the lignification is not uniform over the entire internal surface of the cell walls, but is interrupted in places, forming a relief pattern, at the bottom of which the thickness is the same as that of the cell wall itself, and is also of cellulosic composition. This latter acts as a semi-permeable membrane through which the interchange of soluble matter between adjacent cells is possible and which also functions as a regulator ensuring the maintenance of an even pressure in the fluids throughout the structure of the wood; this is obviously very necessary in order to facilitate an even distribution of watery solutions throughout the plant.

The system of trachieds is built up in very much the same way as the bast bundles, that is to say, the cells do not form a continuously open tube, but instead the end walls remain in existence and fit into one another; communication from cell to cell in any given chain appears to take place by diffusion and osmosis through these walls, but it should be noted that these cannot be compared to the sieve tubes, as there is no protein strand, the cell having died and its contents disappeared long since, leaving only the cellulose wall with its pattern of

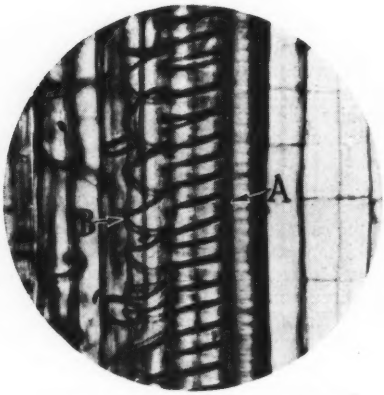


Fig. 56.—Longitudinal section of spirally thickened trachied. Mag. 700 diameters.

lignified thickening, also there are no perforations in the end walls.

The thickening on the walls of the trachieds occurs in several different ways, thus, in Fig 56, we see a photomicrograph of what is known as a spiral trachied, at a magnification of 700 diameters. An examination of the element "A" will show how the lignin is laid down in the form of a spiral along the length of the cell. These trachieds are usually the first to be formed when the tissue in which they occur is laid down. As the plant grows in height, the cell also lengthens due to growth, while the lignin has built up, the net result of which is to separate or open up the spiral, in some cases to quite an appreciable extent, as shown by element "B." The spiral thickening is not necessarily limited to one band, some elements possessing two or more, from which it will be seen that the semi-permeable area is reduced, while the strength of the trachied is improved as the lignin content increases.

Another type of thickening met with

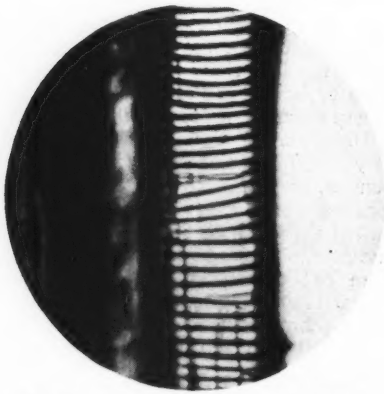


Fig. 57.—Longitudinal section of trachied with circular thickening. Mag. 700 diameters.

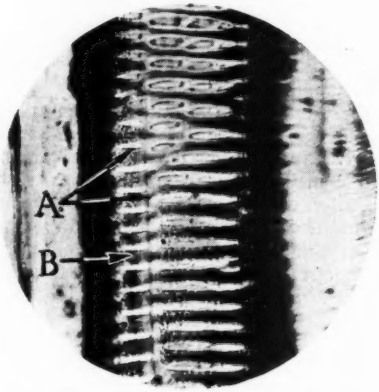


Fig. 58.—Longitudinal section of pitted trachied. Mag. 700 diameters.

is that known as annular. This is shown in Fig. 57, which is a photomicrograph of an annular trachied at 700 diameters In this case, the lignification takes the form of annular rings of lignin arranged one above the other along the length of the cell; here, again, the rings are at first close together, but later become separated owing to their being formed while the cell is still alive.

Other types of thickening occur and are collectively known as "pitted," in which the lignin coating is absent in spots, thereby forming a pit at the bottom of which we again have our cellulose wall. These pits are usually so numerous as to

result in what would appear to be mere ribs of lignin between them. A very good example of this structure is shown in Fig. 58, being a photomicrograph of a typical pitted vessel at 700 diameters, here pits, both large and small, are shown at " A," while at " B " is shown one of the lignin ribs. Sometimes these pits are round and their edges are raised somewhat above the general level of the lignin and overhanging the pit opening. These are referred to as bordered pits; in other cases, each pit functions as a valve.

One well-defined form of pitted thickening is that called scalariform, and shown in Fig. 59 at a magnification of 700 diameters. As its name implies, the pits are elongated as at " A " and lie at right-angles to the major axis of the element. They are usually placed one above the other on each face of a trachied, whose cross-section is polygonal. In this way the structure appears like a ladder. This form of thickening results in much lignification and consequent great strength in the element, while Fig. 60 shows another type of thickening " A " known as reticulate, where the pits take an angular shape and are set so close together as to make the lignin appear as a raised reticulum. In this case the semi-permeable area is obviously large.

Thus we see that the trachieds are composed of chains of cells placed end to end, whose walls undergo lignification in certain directions during life, after the completion of which the cells die, leaving the basic cellulose wall and its lignin to function as a discontinuous vessel distributing nutrient fluids of an aqueous nature throughout the plant, the fluid transport apparently taking place by osmosis through the unlignified portions of the walls of the elements.

In addition to the trachieds, the woody tissue contains other elements in the form of continuous lignified tubes. These originally commenced life as chains of cells, but when lignification was complete and the cells died, the end walls degenerated and disappeared leaving a continuous tube of considerable length

Fig. 59.—Longitudinal section of pitted trachied scalariform pitting. Mag. 700 diameters.

and mechanical strength. These elements are known as vessels and may be lignified in the same way as the trachieds, that is to say, they are thickened spirally or annularly, or they may even be pitted in any of the forms just described. They are, however, by virtue of their structure, more efficient as fluid-transporting members than the trachieds; they are also usually larger in diameter than the trachieds. Thus the largest of the

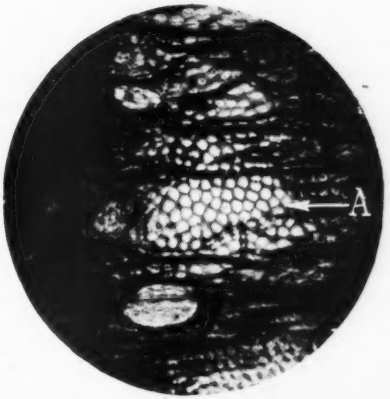
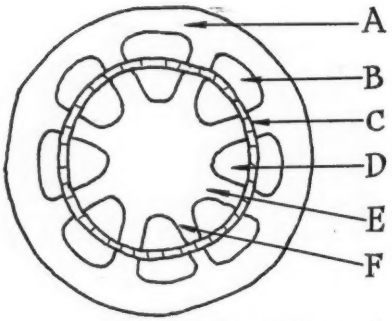
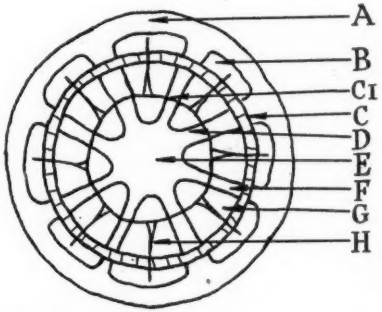


Fig. 60.—Longitudinal section of pitted trachied reticulate thickening. Mag. 700 diameters.





Figs. 61 (left) and 62 (right).—Growth during and after first year.

trachieds are seldom more than 100 μ in diameter (μ = micron = 1/1000 mm.), while vessels 300 μ in diameter are common and frequently reach 700 μ.

We have now briefly studied those tissues of the woody stem which concern us more than the others. They may be tabulated as occurring either outside the cambium or inside, as follows in Table 1:

Table 1.

Tissue element	Location	
Bast fibres	Phloem	Bark
Sieve tubes..	Phloem	Bark
Cambium		
Trachieds	Xylem	
Vessels	Xylem	Wood
Resin ducts..	Xylem	Wood
Xylem parenchyma ..	Xylem	Wood

The portion which we are most concerned with is the wood or xylem, as a mature tree is chiefly xylem tissue, so far as the stem or trunk is concerned. Therefore, having, as it were, sorted out the relevant tissues, let us briefly examine the general development and structure of the stem and see exactly where these tissues are situated. This is best done by reference to diagrams, thus Fig. 61 shows the general structure of a stem during the first year of growth, and shows how the stem is divided into two major portions, separated by the cambial layer "C." That outside the cambium is the living cortex or bark, containing the bundle of bast fibres and sieve tubes "B," collectively known as the phloem. Of this layer, perhaps the only tissue of use to us as a filling material will be the bast fibres, whose mechanical properties need no emphasis. The sieve tubes may be of use for certain specific purposes, but as a rule their mechanical strength would not be sufficient. Inside the cambium we have the large mass of parenchymatous tissues "E," which forms the pith; this communicates with the cortex, through the cambium, by the formation of so-called medullary rays "F," produced automatically by the development of gaps between the bundles of xylem "D."

At the end of the first year of growth a structure similar to this is produced, and during the first winter the cambium ceases activity and obviously growth stops as well. Cambial activity recommences in the spring, and as it is now necessary to get things working as rapidly as possible and large quantities of fluids have to be transported rapidly about the whole plant, this activity of the cambium is very energetic. Fresh xylem is rapidly cut off on the inside and phloem on the outside, as a result of which one may visualize the cambium increasing in diameter while the phloem is pushed outwards. At first large vessels are developed in the xylem, but as the year advances these gradually become smaller until the cessation of activity once more occurs. Thus Fig. 62 shows the stem after the

(Continued on page 90)

Plastics in Germany

The New Target in Germany is the Science behind the Industries. The following are additional Notes from the Official Reports

CIOS XXIII-23.—I.G. Farbenindustrie A.G., Hoechst/Main. While this report deals solely with pharmaceutical preparations and insecticides there are two notes which are interesting to readers of this journal. Enteric coatings for tablets were made from polystyrol-maleic anhydride and applied as a 7 per cent. acetone solution. The second interesting pharmaceutical application of polymers is a suppository base called "Postonal," a polyethylene oxide used in place of cocoa butter. The material does not melt at body temperature but is soluble in water.

CIOS XXV-19.—I.G. Farbenindustrie Wolfen Farbenfabrik, Wolfen, near Halle. Wolfen made a number of synthetic resins, one of which was a substitute for phenolics, and 10 tons per month were made. In this resin phenol was replaced by lignin for condensation with formaldehyde. Ionic exchange resins were also made by the condensation of formaldehyde with phenol or resorcinol. These were claimed to have excellent sodium ion absorbing properties. Similar types of resin were made from both these phenolics but replacing formaldehyde with benzaldehyde. These resins were sold under the trade name of "Wofatit." Wolfen also distilled about 3,000 tons of methyl alcohol for conversion to formaldehyde.

CIOS XXV-20. — Dr. Alexander Wacker, Gesellschaft Fur Elektrochemische Industrie, Burghausen, Germany. This company is one of the outstanding of German concerns engaged in the manufacture of chemicals from acetylene. These include acids, esters and aldehydes made from acetic, butyric and crotonic acids, alcohols, chlorinated organic solvents in addition to monomers such as vinyl acetate and vinyl chloride (450 tons per month) and polymers, including polyvinyl chloride, polyvinyl acetate, polyvinyl alcohol and polyvinyl acetyl to a total tonnage of 400 tons per month. Dr. Wacker was perhaps best known for his artificial shellac, of which 25 tons a month were manufactured. There were two grades made from raw and modified aldehyde resins produced from acetaldehyde in contact with caustic soda. The soft resin made above was heated with tricresylphosphate until the resin had a melting point of 90 degrees. Some 400 tons of polyvinyl emulsions were manufactured here, the acetate being used as an adhesive for plywood, paper and films, and as a binder for water paints.

CIOS XXV-26.—I.G. Farbenindustrie, Mainkur-Hoechst. Among the chemical products made here was Kaurit MKF, a material for crease-resisting fabrics made from melamine. This resin was made at the rate of 30 tons per month. Melamine was produced by a Swiss process to the extent of 40 tons per month, which was to be expanded to 120 tons per month. Maprenal, a condensation product of Melamine and formaldehyde, was produced at the rate of 100 tons per month, which was used for the production of synthetic lacquers. A second form of maprenal was made by condensing benzylguanidine with formaldehyde. Pollon was an acronyl plastic used for waterproofing textiles.

CIOS XXVII-83.—A.G. Fuer Stickstoffduenger Knapsack. This factory has manufactured 25,000 tons of calcium carbide per month, 10,000 tons of calcium cyanamide per month, 6,000 tons of acetaldehyde per month, 400 tons of acetic acid per month and 400 tons of acetone per month.

Coconut Products and the Plastics Industry

By G. B. E. SCHUELER*

WITH the rapid growth of the plastics industry and the rapidly increasing demands on it by the public and all sections of industry, manufacturers and moulders are more than ever concerned with the availability of suitable raw materials.

Apart from the probable advent of new synthetic resins and other plastics, it is obvious, especially when we consider the thermosetting resins, that an important parallel movement during the coming years will be a world-wide search for new desirable fillers.

The primary function of a filler in synthetic resin is undoubtedly that of imparting specific properties to the final structure, ranging from increased strength to improved water resistance, from improved flow in the mould to better electrical properties. In the early days of the plastic industry, when synthetic resins did not exist, asbestos, kieselguhr, slate powder, mica and similar inorganic fillers were commonly incorporated in the asphalts, pitches, tars and natural resins moulded into industrial components. With the introduction of synthetic resins the range has been extended and now includes wood-flour, cotton-linters, chopped cotton cloth, string, metal powders and, more latterly, walnut-shell powder.

The writer hopes to demonstrate that certain of the products of the coconut, especially coconut shell flour, will find a worthy place in this list.

The properties of the filler in moulding powders has been found to depend not only on its chemical nature and its "compatibility" with the resin, but also on the physical structure it possesses naturally and imparted to it during its production prior to mixing in the resin. Thus it is

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not only the botanical origin of wood-flour that is important, but also its absorptive capacity, and also the methods used in grinding, the length of the fibres produced, etc.

In general terms a filler can be described as a "good" filler if it fulfils the following requirements:—

(a) Improves or maintains the desired properties of a moulding as laid down by available specifications.

(b) Is in abundant supply.

(c) Imparts no undesirable chemical or mechanical effects to the die.

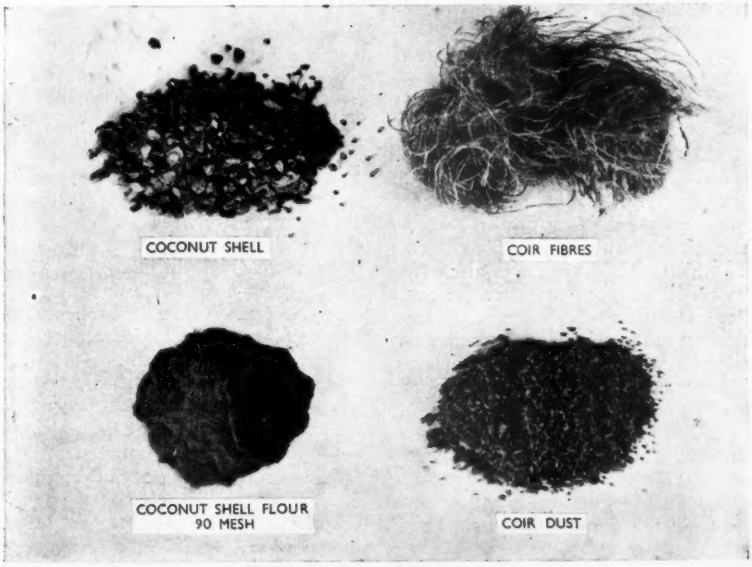
(d) Extends the resin to an important degree compatible with (a). The filler would, especially at the present juncture of the industry, fulfil the most important function of increasing the supply of powder to industry as a whole.

(e) Generally speaking, a filler with powers of extending the resin to a greater degree than those at present in use will cheapen the final moulded article.

For an elementary explanation of the function of fillers it has been assumed that the particles are bonded together individually by the binder. The desired result to be achieved would then appear to be that each particle should be surrounded by a thin layer of binder, for instance, a phenolic resin, these layers then being bonded by heat and pressure. Such a structure would be very different from the structure of natural fibrous materials, in which the fibres form a continuous layer bonded by resin. In the above case the resins form the continuous layer of a honeycombed structure with the particles of filler dispersed in it.

It is evident that the mechanical properties such as flexural and impact strength will be improved the more homogeneously the particles are distributed in the structure. Large aggregations of particles either of filler or resin will be the cause of "weaker points."

In a theoretical structure of this kind, the strength of the moulding will depend on the forces of adhesion between the filler and the resin. In practice, this



The by-products of the industry.

maximum strength is not obtained, but the break will occur at the above-mentioned points.

At first glance it seems improbable that the bond between two different materials such as resin and filler could be greater than between the particles of the same material.

However, it is common knowledge now that many adhesives provide such a strong glue line that breaks occur in the material rather than on the line of bonding. It would, therefore, be quite logical to assume that a stronger bond of adhesion between resin and filler will be effected if the filler itself already contains a high proportion of binder, such as Lignin.

The use of fibres as fillers marks the distinct progress towards the production of plastic products with greater mechanical strength. The interlocking of the fibres provides additional strength apart from the strength due to the resin bond. In this case, the final strength of the article will depend on:—

(1) The extent of the mechanical interlocking of the fibres.

(2) The extent of the coating on the fibres.

(3) The mechanical strength of the fibre and of the resin.

(4) The amount of contact between the fibres.

These facts are confirmed in practice—chopped rag filler gives greater strength than loose fibres—laminated fabrics give greater strength than chopped rag, etc.

These, then, are some basic considerations which will guide us in using the most profitable type of filler. Price is not at the moment a major consideration, as the demand is so much greater than the supply. The question of price, however, will very soon enter into the picture, when export of British plastic products will have to be promoted under more normal conditions.

A filler that will reduce the percentage of resin used without impairing the quality of the product (or may even improve it) should, therefore, be of interest to the plastics industry. The author is of the opinion that the coconut will provide valuable materials for such purposes.

Some interesting experimental work is being carried out at present in America and in this country. American experiments are mainly guided by the experience of using walnut shell flour as filler. This latter material has been in use there since 1941—mainly as a filler for cast resins, and in 1943 the annual consumption by the industry was 4,000,000 lb. of walnut shell flour. The figure for 1944 is expected to be still higher. When used in mouldings it is said to give an exceptionally smooth and lustrous finish, and a higher resistance to moisture and heat than most other fillers.

In view of the dense structure of walnut shell flour, less resin is required to bond the particles. Some of its special properties are attributed to its content of Cutin (a waxlike substance) and to its high content of Lignin, which latter is understood to act as an extender for the resin.

Coconut shell is also being used as a filler to an increasing extent in the States, especially as walnut shell flour has become short in supply.

Properties of the Coconut

For those who may not be familiar with the coconut some particulars of interest are recorded hereunder.

The outer portion of the coconut consists of a relatively thin leather-like outer husk (epicarp or pericarp), thick fibrous layer (mesocarp), which, together with the husk, accounts for about one-third of the nut. A dense, strong shell (endocarp) of approximately ¼-in. thick accounts for a further 10 to 15 per cent. of the weight, and the kernel (endosperm), which in dried form is copra, makes up (together with the milk) the rest of the weight, i.e., approximately 50 per cent.

The main product of the coconut is, of course, the kernel (copra), and the coconut shell is a by-product of this manufacture.

The fibres (coir) are used to a large

extent as materials for the manufacture of ropes, mats, string, brushes, etc., but certain grades of fibres only can be used for these products, and surplus fibres are usually available.

By-products also occur in spinning and other fibre industries, especially in India—combings, clippings and waste fibres. Further, a large amount of dust (coir dust) is produced when the husks are defibrated. This is a cork-like substance which is situated in the husk between the fibres. It therefore appears that the coconut can provide three distinct products for the plastics industry:—

(1) Coconut shell for grinding into coconut shell flour.

(2) Coir dust.

(3) Fibres of different length and quality.

The Coconut Shell

With the experience of walnut shell flour in hand, it seems worth while to examine the possible use of coconut shell as a filler.

The two main disadvantages of walnut shell flour are its scarcity and its consequent fairly high price. Coconut shell, on the other hand, is found in many parts of the globe, and supplies are almost unlimited. Price, in consequence, in normal times is comparatively low.

Recent reports from Malaya and Ceylon show that 250,000,000 nuts per annum are exported. This alone assures us of a potential supply of 40,000 tons of shell per annum, yet such figures are only a small percentage of the total estimated world's supply. In 1939 80 per cent. of the world production was supplied by the following regions:—The Netherlands Indies (25 per cent.), Philippine Islands (22 per cent.), British India (18 per cent.), Ceylon (9 per cent.), Malaya (8 per cent.).

The world production of copra was then estimated at 7⅛ billion lb., which would indicate that the potential production of shells would exceed 3,000,000 tons.

The availability of coconut shell is influenced to what extent the local Indian home consumption uses the coconut. In pre-war days, it was estimated that about half of the world production was consumed by the population, but this percentage has increased in war-time. The shells can only be economically collected as by-product from copra production. In order to dry copra they (the shells) provide the local fuel, and only if transport and other fuel is available can the shells be exported.

The calorific value (2) of coconut shell is approximately 7,500 B.Th.U. per lb. This is approximately the same for wood, which is the alternative local fuel.

Chemical Composition

The table set out below compares the composition of walnut shell and coconut shell and gives a fair indication that the products are very similar.

Table 1.

	Walnut shell[3]	Coconut shell[4]
	Per cent.	Per cent.
Hot water solubles	2.2 - 2.5	2.67
1% NaOH solubles	13.1 -14.8	20.53
Ether solubles	0.16- 0.28	0.19
Alcohol-benzine solubles ..	2.1 - 2.49	—
Alcohol 95% solubles ..	2.3 - 2.56	—
Ash content	0.38- 0.53	0.23
Cutin	1.7 - 6.3	—
Lignin	26.0 -32.0	33.3
Furfural	5.2 - 5.5	—
Pentosans	8.9 - 9.3	17.67
Methoxyl	6.3 - 6.5	5.4
Moisture content of air-dry-material cellulose	59.6 -60.0	61.0

Remarks

Walnut Shell.—Cutin content on the average about 5 per cent. The fact that 33.8 to 39 per cent. of this material is not dissolved in concentrated sulphuric acid (72 per cent.) is important in many applications. Ash (0.38 to 0.53 per cent.) contains calcium, potassium, phosphorus and magnesium. Specific gravity, 1.35 to 1.45; weight of fine walnut shell flour, 29 to 31 lb. per cubic ft.

Coconut Shell.—The yield of lignin, total pentosans and pentosans in the cellulose are higher in shells than in hardwoods, but the percentage of cellulose, cellulose stable to hydrolysis by 15 per cent. sulphuric acid and holocellulose are considerably lower than those for woods.

General

Hot water solubles comprise starchy material, sugars, etc.

One per cent. NaOH solubles comprise pectins, gums, etc.

Lignin, for instance, which acts as an extender to the resin, is present in both to the extent of 33 per cent. This means that less resin should be required to produce the same mechanical properties in the moulding than in the case of other fillers with less lignin content.

At the same time, the fact that shell flour does not absorb resin but binds exceptionally well constitutes a saving in resin.

The high density of the material, for example, coconut shell ground to 150/200 mesh has a density in powder form of 0.7 to 0.75, and this is especially welcome for certain purposes.

Coconut shell flour contains no oil, and this has been clearly proved by ether extraction, which shows the following result:—

Moisture	7.92%
Ether extract on dry material	0.12%
Ether extract on original material	0.11%

This is achieved by careful examination of the coconut shells before they are pulverized, and any which show the slightest trace of copra are discarded. As a constant and reliable chemical composition of the filler is of the greatest importance to the manufacturer of moulding compounds, especially under exacting conditions where he has to work to certain specifications, the coconut shell offers obvious advantages.

In order to enable coconut shell flour to compete with other fillers on the British market, it will be essential that it should be pulverized in India so that it can be more conveniently shipped, and, if in the process waste occurs, it can be replaced locally.

The moulding powder manufacturers will require a material of uniform fineness, similar composition and purity, and strict technical supervision at the source will also be a matter of importance.

Grinding, sifting, transport charges and losses of material in these operations will influence the price, but, in spite of the distance, the material should become a most important raw material by virtue of the valuable properties it imparts to mouldings, such as compactness, saving in synthetic resins, improved flow in the mould, improved water resistance, improved lustrous finish, etc.

An important post-war consideration may be the fact that the public has an established confidence in the coconut shell. For over a thousand years most beautiful and durable articles in the Indian household have been carved from coconut shell. It may well be that the "filler" in this case, not the resin, will be the primary promoter of public confidence in new plastic household lines.

Properties of Mouldings

As is the case with walnut shell flour, the coconut shell flour gives moulded articles an exceptionally smooth and lustrous finish.

Coconut shell requires less resin to bind the moulding compound than most other fillers and improves resistance to moisture and heat, with dielectric strength the same as is the case with walnut shell flour.

Coconut shells do not decompose, even in the tropical climate under exposed conditions, for many years. This property may prove of importance when producing mouldings for export.

Table 2 shows the results of certain physical tests on two mouldings made with diffe ing resin content, compared with a 50/50 resin-wood flour mixture.

Coir Dust

Experiments with coir dust as filler have not yet advanced to such an extent as those of coconut shell flour. Coir dust is highly water absorbent. It will absorb a much greater percentage than the fibres. Coir dust is used to a large extent in the East as a fertilizer, and sometimes as powdered fuel or pressed into briquettes for that purpose.

Table 2.—Comparative physical characteristics of resin/coconut flour mouldings and one made from a mixture of equal quantities of resin and wood flour. The same phenolic resin was used throughout. Tests according to B.S.S. 771.

Test	Material No. 1 Resin .. .. ..100 pts. Coconut Shell Flour..100 pts.			Material No. 2 Resin .. .. .. 50 pts. Coconut Shell Flour..100 pts.			Material No. 3 Resin .. .. ..100 pts. Wood Flour .. ..100 pts.		
Flow	5			8			12		
Cure (seconds)	70			60			62		
Powder Density	0.63			0.68			0.60		
S.G. of Moulding	1.25			—			1.35		
Shrinkage, %	1.09			0.96			0.83		
Water Absorption, m.g..	52			109			86		
	a	b	c	a	b	c	a	b	c
Surface Resistivity megohms (Before immersion	1.45×10^5	1.5×10^5	1.5×10^5	1.15×10^5	1.15×10^5	1.7×10^5	1.3×10^5	1.15×10^5	1.15×10^5
(After immersion	9.0×10^3	8.6×10^3	1.0×10^4	2.0×10^4	7.4×10^4	7.3×10^3	4.1×10^4	4.8×10^4	3.7×10^4
Volume Resistivity megohms (Before immersion	6.0×10^5	6.6×10^5	1.1×10^6	3.9×10^5	5.4×10^5	5.2×10^5	1.9×10^5	6.1×10^4	6.1×10^4
(After immersion	3.5×10^5	4.0×10^4	5.8×10^5	1.1×10^5	1.2×10^5	1.3×10^5	3.5×10^4	3.2×10^4	3.2×10^4
Electric Strength at 90°C. volts/mil. Breakdown ..	103	115	96	73	80	61	43	53	45
Impact Strength, ft./lb. (Average of 5 tests) ..	0.21			0.20			0.17		
Tensile Strength lb./sq. in. (Average of 3 tests) ..	5,166			8,950			8,016		
Plastic Yield at 140°C. in mm.	4.9			2.33			4.3		

An extensive study of the dust has been made by agriculturists (5), and it is stated that coir dust absorbs eight times its weight in water, whilst it parts with it very slowly.

Two per cent. of coir dust in sandy soil will increase its water holding capacity by 40 per cent.

It is approximately 20 per cent. lighter than wood flour compared by bulk. To what extent its absorptive properties can be used is a matter for consideration. Usually this property is not considered an advantage. Recent laboratory tests have shown that, after grinding and sifting, coir dust can be used as a filler.

Experimental mouldings show a tendency to be brittle if coir dust is used as the only filler for the resin. In cases where it is of advantage to introduce absorptive properties to a compact non-absorbent filler, coir dust may serve as a useful admixture.

Tens of thousands of tons of this filler are available from stock, and as its value is low for other purposes, the price is much less than that of coconut shell.

Fibres

Whilst in the plastics industry the use of these fibres has not yet found much application, it is interesting to note that in India valuable materials have been made from coir fibre, using shellac or other local materials as a binder. This manufacture is progressing.

In pre-war days coir fibre, especially the lower grades, were in surplus supply, and when transport becomes available again, this fibre may prove to produce better and cheaper products than Bagasse or other imported fibres.

There is no reason why synthetic binders could not be then used to produce large mouldings. In the meantime it may be of interest to note two Indian processes now in use (6):—

(1) **Packing Material.**—This is made by treating coir fibre with twice-boiled linseed oil for 10 minutes, then centrifuging, whereby one part of oil remains to four parts of coir. It is then placed in a hot press and kept under pressure for four hours at 95 degrees Centigrade.

These materials are used in large quantities for packing ammunition.

(2) **Hard Coir Fibre Boards.**—These are made by beating the coir into a fluff, clipping into small pieces of 0.5 to 1 cm. in the disintegrator, then treating it with a solution of shellac in ammonia which is dried. It is then mixed with twice-boiled linseed oil and exposed to the sun for four hours to promote partial oxidization. After this operation it is pressed at 130 degrees Centigrade with half a ton per sq. in. It is eventually baked in moulds for 30 minutes. The boards are very hard and have a good finish. They do not warp or give fissures by stress and withstand boiling water, dilute soda solution and dilute acids. It can also be made into moulding powders.

Some experiments in pulping coir fibre, using the immature husk with its binding materials contained therein, and adding limited quantities of paper pulp have been carried out by S. R. K. Menon and the Ceylon Coconut Board.

In the opinion of the author, there should be, however, other methods of using coir products and producing a stronger and homogeneous product, especially as it is possible to collect large quantities of a certain type of coir dust and coir fibre. It only needs suitable addition of economic binders to produce a product with high tensile strength.

In summing up, it should be emphasized that one product, i.e., "coconut shell flour," is now available in commercial quantities in Britain, and proves to be a useful filler for mouldings (similar to those moulded of walnut shell flour filler powders in the States).

Fibre and coir dust, which are also available in abundance in the Empire, await the result of further experiments to prove their ultimate use to the industry.

REFERENCES

(1) *"World Trade Notes on Chemical and Allied Products," Vol. 13, No. 41, October 14, 1939, page 705.* **(2)** *"New Zealand Journal of Science," Wellington, Vol. XII, page 15, S. J. H. Wilson, M.Sc., Dominion Laboratory; figures from Dominion Analyst, Dr. J. S. Maclaurin.* **(3)** *"Plastics Catalogue," 1944, page 290.* **(4)** *"The Analyst," Vol. 63, page 86, L. C. Fleck, W. C. van Becken and G. J. Ritter.* **(5)** *"The Tropical Agriculturalist," page 73, "The Decomposition of Coconut Fibre Dust," by A. W. R. Joachim, 1929.* **(6)** *"Journal of Scientific and Industrial Research," Vol. 11, No. 3, April, 1944, "Industrial Utilisation of Coir."*

MICROSCOPIC EXAMINATION

(continued from page 82)

first year's growth, the original or primary xylem occupies the same position and has been added to by the increase shown at "G." Although not shown in the diagram, this mass of secondary xylem forms an almost continuous ring, with the medullary rays "F" much reduced in width. Furthermore, the new or secondary xylem develops additional medullary rays, as shown at "H"; these are known as secondary rays.

Thus, as a result of the second year's growth, we have the addition of a ring of fresh xylem tissue, whose inner boundary lies at the original site of the cambium "C1," and whose outer boundary is occupied by the now extended cambium. This secondary xylem is more closely packed than the original, having less parenchymatous tissue dispersed through it, from which we see the annular rings.

As the tree gets older and the trunk increases in diameter, the tissues at the centre are used less and less for nutrient transport, and they begin to function more as pure supporting tissues, frequently where there is much parenchymatous tissues, this rots away leaving the trunk hollow. This inner, relatively dry, portion of the trunk is called heart wood, while the outer, still conducting, portion is known as sap wood. Obviously, the most useful portion of the trunk for our purpose is the heart wood, fully developed as a strengthening tissue.

(To be continued)

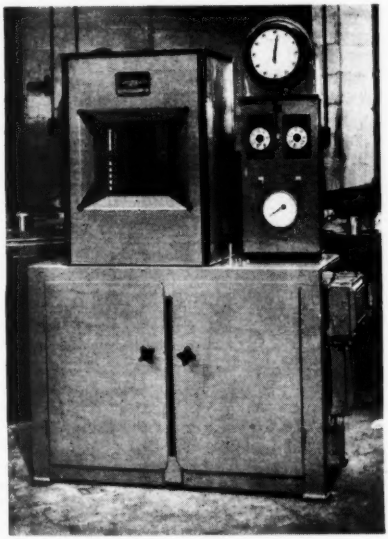
PRODUCTION NEWS

Raw Materials, New Plant, Works Organization, Control Apparatus, Research, Personal and Trade Notes

A.P.L. UPSTROKING PRESS.—We have received from Aircraft Precision, Ltd., Croydon, details of their 30-50-ton upstroking hydraulic press.

The main ram is of 6-in. diameter mild steel and is fitted with Walker "Lion Twinset" packing, and the cylinder is of close-grain cast iron fitted with a gland for easy replacement of packing. The columns are of 2½-in. diameter mild steel, machined all over, and the moving table is fitted with phosphor-bronze bushings working freely with the columns.

Generally speaking, the press is of the



gravity return type, but six springs provide the initial opening. The stroke is 8 ins. and the daylight 12 ins.

The auxiliary equipment includes electrically heated platens (15 ins. by 15 ins. by 2 ins.), thermostatic control, and temperature and pressure-indicating dials.

A Dowty Live Line Pump with a capacity of 820 cubic ins. at 2,800 lb. per sq. in., driven by an 8 h.p. 3-phase 400-440 motor, is suggested to operate the unit.

The price (without motor and pump but including pipes, brackets, etc.) is £298 10s.

"BRITAIN CAN MAKE IT" EXHIBITION.—The British Plastics Federation has been requested by the Council of Industrial Design to assist in the arrangements for the exhibition of plastic articles at the "Britain Can Make It" Exhibition to be held by the Council in the summer of 1946. The Exhibition will cover all the main ranges of consumer goods, and all firms of the Plastic Industry who are interested in exhibiting articles are requested to write to The British Plastics Federation, 47, Piccadilly, London, W.1.

THE BOARD OF TRADE is proposing to lay an Order before Parliament in the near future with a view to scheduling two new areas as Development Areas under the Distribution of Industry Act. The areas concerned are the borough of Wrexham and certain adjoining districts, and the county boroughs of Wigan and St. Helens and certain nearby districts.

The Wrexham Development Area, it is suggested, should be managed by the existing Welsh Trading Estate Company under the chairmanship of Col. Sir Gerald Bruce, who will make suitable arrangements for local representation. An entirely new Government-financed trading estate company is proposed to manage the Wigan St. Helens Development Area, and Mr. George Gibson has consented to become the chairman. Mr. Gibson is chairman of the North-West Regional Board of the Board of Trade.

CIVILIAN PRODUCTION.—The Board of Trade report progress in reconversion of industry in a number of trades, from which is noted the following:—

Radio.—Licences issued under the new programme for proprietary wireless receivers now cover 878,000 sets for the home market and 489,000 for export. Up to the end of October, 18,550 sets had been completed under the new programme, of which 1,382 were exported. Export figures for all wireless receivers in October were 2,379 compared with 944 in June.

Corsets and Brassieres.—All types of corset elastic are being switched from 100 per cent. synthetic rubber to 25 per cent. crude rubber and 75 per cent. synthetic. A release of liquid latex by the Rubber

Control will give a 50 per cent. increase in production of high quality elastic fabrics. Future production of suspenders will have rubber buttons instead of the plastic substitutes.

Footwear.—Production of leather footwear during October was at the rate of 9,400,000 pairs compared with 8,100,000 pairs during September. The labour force in leather footwear firms increased from 69,700 in September to 70,700 in October. Special steps were taken to direct Service and prisoner-of-war labour into the tanning industry to deal with the accumulation of hides caused by the dock strike. It is estimated that the hold-up will result in a reduction of not more than 10 per cent. in the supplies it had been anticipated would be available in the first quarter of 1946. It is expected that the shortage of upper leather will be eased by the introduction of fabric coated with P.V.C.

NATIONAL PHYSICAL LABORATORY.—Mr. F. H. Rolt, M.B.E., B.Sc., M.I.Mech.E., has been selected for the appointment of Superintendent of the Metrology Division of the National Physical Laboratory, with effect from April 1, 1946, on the retirement from that post of Mr. J. E. Sears, C.B.E. Mr. Rolt has been a member of the staff of the National Physical Laboratory since 1912, but during the war his services have been lent to the Ministry of Supply, where he has held the post of Director of Jigs, Tools and Gauges.

Mr. A. Fage, F.R.S., has been appointed Superintendent of the Aerodynamics Division of the National Physical Laboratory, with effect from January 1, 1946, to fill the vacancy caused by the resignation of Mr. E. F. Relf, F.R.S., who is taking up the post of Principal of the College of Aeronautics. Mr. Fage has been a member of the staff of the National Physical Laboratory since 1914.

HORNERS COMPANY HONOURS E. K. COLE DIRECTOR.—It will be recalled that the Worshipful Company of Horners has decided to associate itself with the plastics industry, thus linking the centuries-old craft of making utensils from animal horn with its modern counterpart. In this connection Mr. N. C. Robertson, M.B.E., Deputy Managing Director of E. K. Cole Limited, has been admitted into the Livery of the Guild at a meeting of their Court in the ancient Tallow Chandlers' Hall, London.

E. K. COLE, LTD., has appointed Mr. C. Clark Ramsay Press Relations Executive in their publicity department. His work will no doubt be connected with the company's rapidly expanding plastics division.

Mr. Ramsay has been in publishing all his life and in 1935 became advertising manager of the Book Departments of George Newnes, Ltd., and C. Arthur Pearson, Ltd.

J. F. KENURE, LTD., and DURATUBE AND WIRE, LTD., have now extended the field of their activities in plastics and are now associated with Dalebrook, Ltd., of Goldhawk Road, W.12. The work undertaken by these three associated companies is as follows:—Injection Mouldings and all kinds of Plastic Manipulations by J. F. Kenure, Ltd. Extruded Thermoplastics (Durawire, Duracable, Duratube, Durabelt, Durastrip, Durasleeve, etc.) by Duratube and Wire, Ltd. Plastic Flowers, Decorations and any other kind of artificial flower by Dalebrook, Ltd.

Mr. John F. Kenure is the Managing Director of each of these companies.

MICANITE AND INSULATORS CO., LTD., inform us that Sir George E. Bailey, C.B.E., Managing Director of Associated Electrical Industries, Ltd., and Chairman of Metropolitan-Vickers Electrical Co., Ltd., has joined the Board of the Micanite and Insulators Co., Ltd.

MR. D. W. COOPER, who, in February, 1942, was seconded from **George Cohen Sons and Co. Ltd.** to take up the appointment of Assistant Controller of Machine Tools at the Machine Tool Control, and has for the past year been Director of Machine Tool Disposals, has joined the Board of the **Selson Machine Tool Co. Ltd.** Selson's are, of course, one of the 600 group of companies of which George Cohen Sons and Co. Ltd. are the parent concern, and Mr. Cooper will not be severing his connection with them.

H. COURTNEY BRYSON, after many years' service, has relinquished his position as chief chemist to Messrs. Scott Bader and Co., Ltd., in order to concentrate his entire activities as managing director of Bryson Processes, Ltd., at Station Road, Irthlingborough, Northants, where he will continue his work on the production of new synthetic resins and emulsions for technical purposes as well as allied materials such as adhesives, leather finishes and waxes. The London

offices of the company are at 312, Sardinia House, Kingsway, W.C.2. Telephone, Holborn 6277.

EDWARD A. O'NEAL has been appointed to the board of Monsanto Chemicals, Ltd., as deputy managing director. Mr. O'Neal has been associated with the Monsanto Chemical Co., of St. Louis, Missouri, U.S.A., since 1926. Since 1941 he has been production manager of the phosphate division of that company.

F. A. HUGHES AND CO., LTD., announce that they have arranged for the following additional personnel to join their Headquarters at Abbey House, Baker Street, London, N.W.1 (telephone number Welbeck 2332):—

Mr. D. N. Davies, B.Sc., A.R.I.C., A.M.I.Chem.E., late of Cellomold, Ltd., who becomes Chief Technical Assistant on thermosetting products. Dr. S. J. Skinner, Ph.D., B.Sc., A.I.R.I.(Sc.), late of the Ministry of Supply, C.R.D., Berkeley Court, W.1, who will be responsible for technical service on rubber-like plastics and other thermoplastic products. Mr. S. R. Badley, late of Cellomold, Ltd., who will be responsible for technical service on synthetic resin adhesives.

These arrangements have been made to provide all customers of F. A. Hughes and Co., Ltd., with the best possible technical service covering the enlarged range of plastic products now being manufactured at the works of the following subsidiary companies of The Distillers Co., Ltd.:—British Resin Products, Ltd., of Tonbridge; Cellomold, Ltd., and Extruded Plastics, Ltd., of Feltham; and Indurite Moulding Powders, Ltd., of Manchester.

MR. GEORGE A. STREET, one of the original members of the Midlands Section, severed his connection with the plastics industry when he retired on December 31, 1945. He had been with I.C.I. for many years.

At a farewell luncheon given in his honour on December 28, the Section Chairman, Mr. F. L. Dinenage, in his opening remarks said that he had received a letter from the Chairman of Council of the Institute addressed to Mr. Street, which intimated that Council had unanimously agreed to make him an Honorary Member of the Institute. He asked Mr. Street to accept this letter, which had been suitably framed.

Mr. A. G. Snell, in a brief survey of his activities in the Industry, asked Mr. Street to accept from the Committee and a few friends as a token of their respect and regard a silver cigarette box suitably engraved, and for Mrs. Street a handbag.

Mr. Street, in his usual and inimitable manner when acknowledging the gifts, said that while he would always prize them as a token of the friendship he had made, the thing that delighted him most was the letter signed by the Chairman of the Institute, which meant that although he was retiring from business he would still be able to attend all meetings and thus not lose contact with his many friends in the Institute.

MR. CHARLES L. BRITTON AND MR. HARRY MOORE, both members of the staff of Bakelite, Ltd., have been awarded the British Empire Medal (Civil Division) in the New Year's Honours List.

MISS ELLEN MATTHEWS AND MR. GEORGE BERRY, both employees of Halex, Ltd., have also been named in the recent Honours List. Miss Matthews has been awarded the B.E.M. in recognition of her sterling worth at the factory during the war, during which period she concentrated on the manufacture of combs. She has been employed at Hale End for 26 years. Mr. Berry is foreman of the mechanical engineering department, and had the responsibility of maintaining production of many articles never previously made in plastics. He joined the company in 1914.

THE INSTITUTE OF THE PLASTICS INDUSTRY.—Midlands Section. A luncheon of this section will be held on March 1, at the Botanical Gardens, Edgbaston, Birmingham, 15. All members and their friends are cordially invited.

ELECTRICITY METER AND ALLIED INDUSTRIES, LTD., of Joynton Avenue, Waterloo, Sydney, have been appointed Australian representatives for the De La Rue group of companies manufacturing plastics.

BRITISH POWER ALLOYS AND PLASTICS CO., LTD., Waters Road, Kingswood, Bristol, has been registered as a private company.

ERRATUM

In the article entitled "Lining Tanks with Vinidur" ("Plastics," Dec. 1945, p. 617), the first reference should read: "The whole subject is extensively discussed in a book by W. Krannich: Kunstoffe im technischen Korrosionsschutz, Handbuch für Vinidur und Oppanol, published by F. Lehmann, Muenchen and Berlin, 1943.

PATENT REVIEW

B.P. 572,331. Application date: 9.5.43. Convention date (U.S.A.): 26.2.42. Accepted: 3.10.45.

Improved Polymeric Silicone and Methods of Making it. R. R. MacGregor and E. L. Warwick. To: Corning Glass Works.

Method for the preparation of a liquid having a low pour point and a low temperature coefficient of viscosity by refluxing dimethyl-diethoxy-silicone in the presence of water and hydrochloric acid and recovering the dimethyl-silicone polymer. Refluxing is carried out for at least one hour. Subsequently the reaction product is heated to at least 230 degrees C., washed, and the water removed. The reaction is carried out in an inert atmosphere.

B.P. 572,401. Application date: 25.5.44. Convention date (U.S.A.): 10.6.43. Accepted: 5.10.45.

Improved Polymeric Silicone and Methods of Making it. R. R. MacGregor and E. L. Warwick. To: Corning Glass Works.

An improvement on the process mentioned in B.P. 572,331 characterized by hydrolizing dimethyl-diethoxy-silicone in the presence of an acid, distilling the hydrolysis product in order to recover polymers, boiling below 250 degrees C. at reduced pressure, treating these polymers with hydrohalic acid; and fractional distillation of the product to separate dimethyl silicones with up to 12 Si-atoms per molecule.

B.P. 572,410. Application date: 21.10.40. Accepted: 8.10.45.

Improvements in or Relating to the Manufacture of Styrene from Ethyl-Benzene. H. M. Stanley and F. E. Salt. To: The Distillers Co., Ltd.

Method for producing styrene from ethylbenzene by passing ethylbenzene vapours alone or mixed with steam over a vanadium oxide catalyst at temperatures near to 600 degrees C. The catalyst may be supported by granules of alumina or magnesia and may be revived by heating to a temperature above 500 degrees C. in the presence of oxygen.

B.P. 572,425. Application date: 12.10.43. Convention date (U.S.A.): 11.12.42. Accepted: 8.10.45.

Improvements in or Relating to the Moulding of Thermo-setting Plastics. Bakelite, Ltd.

Discloses details for high-frequency moulding of thermo-setting resins; energy is supplied at such a rate that the hardening temperature is reached before hardening sets in so that proper flow within the mould takes place. Frequencies concerned vary from 1-1,000 Mc/sec.

B.P. 572,443. Application date: 13.7.43. Convention date: U.S.A. 31.7.42. Accepted: 9.10.45.

Improvements in or relating to Radio Frequency Heating. Radio Corporation of America.

High-frequency spot welding gun for setting for veneers.

B.P. 572,445. Application date: 1.12.43. Accepted: 9.10.45.

Improvements in and relating to the production of Synthetic Resins and of Coating Compositions derived therefrom. G. F. Wilkinson. To: Pinchin Johnson and Co.

Process for preparing a synthetic resin by polymerization of the addition product of beta-naphthol and maleic anhydride at elevated temperatures. This resin is esterified by means of mono- or polyhydric alcohols and then dissolved in a suitable solvent to form a varnish or a vehicle for paint.

B.P. 572,475. Application date: 11.11.41. Convention date: U.S.A. 30.11.40. Accepted: 10.10.45.

An improved manufacture of vulcanizable Polymers from Diolefins. Standard Oil Development Co., New Jersey.

Relates to the polymerization of butadiene containing mixtures in emulsion form and especially to methods for speeding up the polymerization reaction and improving the properties of the polymer so obtained. A diolefin (butadiene) and acrylonitrile are emulsified in water in the presence of an emulsifying agent and hydrogen peroxide is added as a catalyst. The pH of the solution is kept between 8.1 to 8.8 and the temperature raised progressively as polymerization proceeds.

B.P. 572,557. Application date: 29.10.43. Convention date: U.S.A. 10.11.42. Accepted: 12.10.45.

Improvements in or relating to Film Extrusion Apparatus. British Cellophane, Ltd.

Method of extruding viscose film with a

pressure extrusion machine, using orifices which can be adjusted independently. Extrusion takes place into a coagulating bath, the adjusting screws being accessible above the liquid of the bath.

B.P. 572,575. Application date: 24.12.40. Accepted: 15.10.45.

Improvements in and relating to the Preparation of Oil-resisting Rubbers. E. H. Farmer. To: British Rubber Producers Research Association.

B.P. 572,588. Application date: 7.10.43. Accepted: 15.10.45.

Improvements in or relating to the Production of Expanded Plastic Materials. A. Cooper. To: Expanded Rubber Co., Ltd.

Production of expanded plastics of the polyvinyl or ethenoid types from liquid monomers or low polymers, by heating the material in the early stages of polymerization at temperatures of 60 degrees to 70 degrees C., until the material polymerizes to a rubbery consistency. The material is subsequently subjected to a gas under 5,000 lb./sq. in. pressure at room temperature or temperatures up to 110 degrees C.

B.P. 572,634. Application date: 28.2.41. Accepted: 17.10.45.

Improvements in the Plasticization of Rubber and the like. D. F. Twiss, A. J. Hughes and P. H. Amphlett. To: Dunlop Rubber Co., Ltd.

Method of plasticizing rubber or the like by applying or incorporating a naphtenic acid or salts thereof and in particular zinc-naphtenate, in proportions not exceeding 5 per cent.

B.P. 572,670. Application date: 23.7.41. Accepted: 18.10.45.

Improvements in or relating to the Manufacture of Synthetic Plastic Materials. J. J. P. Staudinger and H. M. Hutchinson. To: The Distillers Co., Ltd.

Process for manufacturing thick sheets or blocks of synthetic resins, which are clear and free from strains and bubbles and are suitable for optical purposes. Refers mainly to styrene.

B.P. 572,671. Application date: 1.8.41. Accepted: 18.10.45.

Improvements relating to the Manufacture of Rubber-like Substances. J. R. Whinfield and W. K. Bertwistle.

Method for making rubber-like substances by reacting a dialkylol tertiary amine with a dicarboxylic acid under heat until polymerization occurs.

B.P. 572,676. Application dates: 10.9.42, 30.9.42. Accepted: 18.10.45.

Improvements in or relating to Plastic compositions of a putty-like nature or in or relating to the use thereof. L. E. Puddefoot. To: B.B. Chemical Co., Ltd.

Putty-like composition which may be used to protect exposed parts of motor vehicles (sparking plugs, distributor casings, etc.), so that such vehicles can be driven through water. The composition claimed consists of blown castor oil, a hardened rosin and a filler (asbestos, mica, french chalk, etc.).

B.P. 572,683. Application date: 29.10.43. Accepted: 18.10.45.

Improvements in or relating to Plastic Material in Form adapted for use for Packing or Sealing Purposes. F. A. Ross and J. Crawford. To: B.B. Chemical Co., Ltd.

Production of plastic sealing material in string, tape or other form convenient for use in packing or sealing of articles. Materials consist of a composition comprising a non-drying oil, a thermoplastic resin, a filler of fibrous material and a flexible, permeable sleeve as a container.

B.P. 572,695. Application date: 2.1.40. Accepted: 19.10.45.

Pulverulent Polythenes and Dispersions produced therefrom. C. F. Flint and R. B. F. F. Clarke. To: Imperial Chemical Industries, Ltd.

Method of producing pulverulent or friable polythene by heating horny polythene with up to 25 per cent. of oleaginous material or a modifying agent to at least 100 degrees C., and subsequent working this mixture until plastic. Cooling it down to 60-80 degrees C. and further working makes the material friable. Aqueous dispersions of this product may be used to coat textiles or to produce films, threads, etc.

B.P. 572,707. Application date: 27.8.41. Accepted: 19.10.45.

Process for the stabilization of organic Halogen Compounds of high molecular weight. J. R. Myles and W. J. Levy. To: Imperial Chemical Industries, Ltd.

Process for stabilizing compositions containing high molecular weight organic halogen compounds against the action of heat or light by incorporating .5-5 per cent. of at least one carbinol, ester or ether (and triphenyl methyl ether or ester in particular).

B.P. 572,720. Application date: 26.11.43. Convention date: U.S.A., 6.11.42. Accepted: 19.10.45.

Synthetic Rubber Compositions. K. E. Marple. To: Shell Development Co.

Synthetic rubber composition comprising a copolymer of butadiene with acrylonitrile or styrene and diallyl phthalate as softener.

B.P. 572,728. Application dates: 24.7.41, 12.12.41. Accepted: 22.10.45.

Improvements in and relating to the Production of Cellulose from Lignin-containing Cellulosic Material. W. G. Campbell and D. F. Packman. To: Forest Products Research Laboratory, Princes Risborough.

Process for the production of cellulose from cellulosic materials containing lignin (from 17 per cent. upwards) by treatment with nitric acid at atmospheric pressure and temperatures between 90 degrees to 100 degrees C. Sulphuric acid may be added to increase the reaction speed. Subsequent digestion with alkaline solutions removes the lignin.

B.P. 572,738. Application date: 10.11,41. Accepted: 22.10.45.

Improvements in Polymeric Materials. D. A. Harper. To: Imperial Chemical Industries, Ltd.

Relates particularly to polyesters or polyester-amides which have been treated with diisocyanates. These materials may be improved in their physical properties by working them whilst in a plastic condition. Such working may be performed on a rubber mill at elevated temperatures.

B.P. 572,741. Application date: 1.1.43. Convention date: Canada, 27.8.42. Accepted: 22.10.45.

Process for sticking together Layers of Flexible Sheet Material. G. O. Morrison and T. P. G. Shaw. To: Shawingan Chemicals, Ltd.

Process for bonding sheet materials using on at least one of the sheets to be bonded a highly adherent coating consisting of a water-soluble fusible partially hydrolized polyvinyl acetate having a P.V.A. content of 20 to 50 per cent. by weight. Bonding is effected by heat and pressure.

B.P. 572,748. Application date: 27.1.44. Accepted: 22.10.45.

Improvements in or relating to the Moulding of Plastics. J. Johnson.

Automatic process for compression moulding of plastics. A split multi-component die is used, heated by electrical means. A thermostat controls the temperature and moulding pressure is applied at the right temperature by automatic means. The thermostat operates from three thermocouples in a differential circuit.

B.P. 572,753. Application date: 18.4.44. Accepted: 22.10.45.

Improvements in or relating to the Vulcanization of Rubber. H. W. K. Jennings (Sturtevant Co.).

Process for vulcanizing rubber-covered wire uses a number of vertical tubes through which the wire passes into a zone of superheated steam for curing purposes. The open lower and upper ends of the tubes are provided with an air-seal induced by a suction device. Care is exercised to prevent the passage of moisture at the lower ends of the tubes.

B.P. 572,767. Application date: 3.12.41. Accepted: 23.10.45.

Improvements in or relating to the manufacture of Polymerization Products from polymerizable organic chlorine compounds. J. J. P. Staudinger and M. D. Cooke. To: Distillers Co., Ltd.

Process for the production of polyvinyl chloride by heating liquid vinyl chloride in the absence of water, in admixture with methanol, in the presence of a peroxide catalyst and a compound which can react with the hydrogen chloride contained in or evolved by the vinyl chloride during heating. (This compound may be cyclohexene oxide or the reaction product of sodium hypochloride and alpha-naphthaquinone.)

B.P. 572,768. Application date: 13.12.41. Accepted: 23.10.45.

Improvements in or relating to the Purification of Resinous Rubber Transformation Products. S. R. W. Martin. To: Albert Product, Ltd.

Method of purifying products obtained by heating vulcanized or unvulcanized rubber with phenol and acid anhydrides which have an isomerizing effect. Process consists of dissolving the reaction mass in a hot aliphatic hydrocarbon or petroleum solvent, the isomerizing acids in the hot solution being neutralized with alkali. These solvents will dissolve the whole mass, including phenolic compounds, and on cooling will precipitate these while retaining the rubber transformation products in solution.

B.P. 572,798. Application date: 12.1.42. Accepted: 24.10.45.

Improvements in or relating to the Production of Artificial Films or Filaments having a basis of Alginic Material. J. B. Speakman and N. H. Chamberlain. To: Cefoil, Ltd.

Method for producing alkali-resistant films or filaments made of alginic material

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(e.g., sodium alginate) by treatment with aldehydes (e.g., formaldehyde) in the presence of an acid substance at elevated temperatures until coagulated material comprises molecules linked by methylene groups.

B.P. 572,803. Application dates: 2.2.42, 15.12.42. Accepted: 24.10.45.

Process for the Production of Nitroethylene and Polymers derived therefrom. A. E. W. Smith, R. H. Stanley and C. W. Scaife. To: Imperial Chemical Industries, Ltd.

B.P. 572,827. Application date: 26.2.42. Convention date: U.S.A. 16.5.41. Accepted: 25.10.45.

The Preparation of Copolymers from substituted Acrylonitriles and 1-3 Butadiene or derivatives thereof. To: Wingfoot Corporation, Akron.

B.P. 572,828. Application date: 27.2.42. Accepted: 25.10.45.

Improvements in and relating to Synthetic Resinous Condensation Products and Moulding Compositions produced therefrom. F. J. W. Popham. To: British Rubber Producers' Research Association.

Process for preparing rubber-modified synthetic resinous condensation products by heating a mixture of oxidized rubber (dissolved in phenol or phenol hydrate) with formaldehyde and an acid catalyst to approximately 100 degrees C. The acid catalyst may consist of oxalic, formic or maleic acid in proportions up to 4 per cent. calculated on the rubber.

B.P. 572,829. Application date: 28.2.42. Convention date: U.S.A. 28.2.41. Accepted: 25.8.45.

Preparation of Resin Intermediates and their Aldehyde Condensation Products. To: American Cyanamid Co.

Condensation products useful for compounding of coating, moulding and adhesive compositions, prepared by reacting an amine and dicyandiamide under heat and pressure in the presence of zinc chloride as catalyst. (The amine employed is aniline or orthosolvindine.) These intermediates are then reacted with an aldehyde (formaldehyde) under reflux in the presence of a water miscible alcohol.

B.P. 572,830. Application date: 2.3.42. Accepted: 25.10.45.

Improvements in the Production of Emulsions or Compositions of or containing organic Polysulphides and articles produced therefrom. J. R. Blanco, A. E. T. Neale and D. F. Twiss. To: Dunlop Rubber Co., Ltd.

B.P. 572,857. Application date: 25.3.42. Accepted: 26.10.45.

Improvements in or relating to the Manufacture of Synthetic Resins. J. D. Morgan and B. Frenkel. To: Distillers Co., Ltd.

Relates to the manufacture of synthetic resins formed by the condensation of xylenols or their homologues with formaldehyde, or with a mixture of formaldehyde and acetaldehyde. The resins so obtained are thermo hardening, useful as moulding powders or for the preparation of varnishes. They may also be used for impregnating purposes in the molten condition.

B.P. 572,858. Application date: 30.3.42. Accepted: 26.10.45.

A process for the Production of Synthetic Resins. J. G. Fife. Communicated by: Shell Development Co.

Process for the production of synthetic resins by polymerizing an unsaturated ester (e.g., diallyl diglycollate) in the presence of a catalyst such as peroxide, alkali metal persalt or an oxygen-containing gas.

B.P. 572,862. Application date: 13.4.42. Accepted: 26.10.45.

Improvements in the Manufacture of Adhesive Compositions. K. C. Roberts. To: British Rubber Producers' Research Association.

Method of producing condensation products of a sticky or tacky nature resistant to petrol and mineral oils and other hydrocarbons. Process comprises reacting rubber with maleic anhydride in solution at elevated temperatures and with one or more monohydric alcohols in the presence of an organic peroxide catalyst.

B.P. 572,875. Application date: 31.8.43. Convention date: U.S.A. 30.3.43. Accepted: 26.10.45.

Improvements in or relating to the Treatment of Polymeric Materials. To: Wingfoot Corporation, Akron.

Method for improving the tensile strength of a vinyl chloride-vinylidene chloride copolymer by incorporating 1-10 per cent. of hexamethylene tetramine and subsequent heating to temperatures between 240 degrees and 360 degrees F. for a period of 15-60 minutes in the presence of an acid inhibitor or acceptor such as MgO, Na_2CO_3 or CaO. (The copolymer claimed contains 10-25 per cent. vinylidene chloride.)

B.P. 572,878. Application date: 2.9.43. Convention date: U.S.A. 3.10.42. Accepted: 26.10.45.

Polymers and Copolymers from Chloro-

acrylophenones. To: Wingfoot Corporation, Akron.

B.P. 572,910. Application date: 4.10.43. Convention date: U.S.A. 5.10.42. Accepted: 29.10.45.

Improvements in or relating to the Production of Vinyl Trimethylacetate and Copolymers thereof. To: E. I. Du Pont de Nemours and Co., Delaware.

B.P. 572,914. Application date: 4.10.43. Convention date: U.S.A. 5.10.42. Accepted: 29.10.45.

Improvements in or relating to the Production of Synthetic Resins. To: E. I. Du Pont de Nemours and Co.

Process for polymerizing vinyl trimethylacetate together with one other polymerizable compound (vinyl acetate, vinyl chloride, acrylic acid, methyl methacrylate, etc.) in the presence of a catalyst. The products so obtained have higher softening points and greater resistance to solvents and hydrolizing conditions than the polymers of the individual compounds.

B.P. 572,919. Application date: 29.4.42. Convention date: U.S.A. 1.5.41. Accepted: 30.10.45.

Soft Synthetic Rubber-like Masses. To: Monsanto Chemical Co.

Process for the preparation of plastic material by polymerizing a mixture of a butadiene—1:3 hydrocarbon (or halogen derivative thereof) and a vinyl benzene in the presence of 0.5-5 per cent. of a drying oil (e.g., tung oil).

B.P. 572,923. Application date: 15.5.42. Accepted: 30.10.45.

Improvement in the preparation of Compositions of Rubber or the like and the Incorporation therein of Vulcanized Rubber or the like. D. F. Twiss and A. J. Hughes. To: Dunlop Rubber Co., Ltd.

B.P. 572,933. Application date: 17.8.43. Accepted: 30.10.45.

Improvements in and relating to Means for Use in Drying and Curing Plastics and the like. J. C. Nicholson.

Portable plant for the drying and curing of rubber or synthetics especially in the form of coatings or impregnated layers, consists of a heating apparatus, a compressor and a heating chamber. Hot gases and products of combustion are blown through the heating chamber under controlled conditions.

B.P. 572,946. Application date: 4.10.43. Convention date: U.S.A. 31.7.40. Accepted: 30.10.45.

Copolymers of asymetrical Dichloroethylene with Polymerizable unsaturated Ketones. To: Imperial Chemical Industries, Ltd.

B.P. 572,963. Application date: 15.6.43. Convention date: U.S.A. 8.6.42. Accepted: 31.10.45.

Conversion of Vinyl Type Halides to Aldehydes or Ketones. H. de V. Finch and K. E. Marple. To: Shell Development Co.

Method of converting non-tertiary vinyl-type unsaturated halides with at least four carbon atoms per molecule into aldehydes or ketones, by reacting them with water in the presence of a strong oxy-acid (e.g., sulphuric acid). Refers particularly to 2-chlorobutene-2.

B.P. 572,985. Application date: 20.2.42. Accepted: 1.11.45.

Improvements in or relating to the Treatment of Plastic Surfaces. J. J. P. Staudinger, H. M. Hutchinson. To: Distillers Co., Ltd.

Method of making the surface of a plastic, such as phenol-aldehyde, polystyrene, coumarone, indene and copolymerization products of these, hydrophilic, in order to apply water-soluble dyes. The surfaces are treated with liquid H_2SO_4, fuming H_2SO_4, or chlorosulphonic acid or vapours of these or of SO_3. Depth of colouring depends on time and temperature of treatment process.

B.P. 572,986. Application date: 13.5.42. Convention date: U.S.A. 17.5.41. Accepted: 1.11.45.

Improvements in or relating to Phenol-aldehyde Resins. Bakelite, Ltd.

Process for hardening a liquid heat-reacting phenol-aldehyde resin by incorporating as hardening agent sulphonic acid or salts thereof. This hardening agent may amount to up to 30 per cent. of the weight of the resin, and may also contain 2-15 per cent. of a dihydric phenol (e.g., resorcinol). The pH of the liquid resin is reduced below 6, and preferably below 3.0, by addition of the hardening agent.

B.P. 573,015. Application date: 24.6.42. Accepted: 2.11.45.

Improvements in or relating to the Manufacture of Artificial Textile Fibres. R. L. Wormell. To: Courtaulds, Ltd.

Method of producing artificial fibres from proteins which are more resistant to action of sodium carbonate solutions. Production by extrusion in an acid bath, and subsequent treatment with a solution of a zinc salt in absence of the acid. Refers to casein, ground nut, pea nut and similar protein products.

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The Determination of Moisture in Plastic Moulding Powders by the Karl Fischer Process

By G. R. CORNISH, B.Sc., A.R.I.C. (Halex, Ltd. London, E.C.4)

THE procedure originally introduced by Karl Fischer for the estimation of traces of water in solids and liquids (1) has been modified and adapted for the determination of the moisture content of plastic moulding powders. This latter value is of great importance both with thermoplastic and thermosetting materials; a high moisture content can in many cases have an adverse effect on the injection or compression mouldings produced from the powder. In the Halex laboratory it has been the practice to set a standard critical maximum value beyond which we have considered powders unsuitable for use. The figure naturally varies with the type of material. There are several relative methods of moisture determination (2), some based on measurement of electrical properties, but none of the latter have so far proved very satisfactory owing to the irregular packing effects produced by the large particles of moulding powders. During our search for a reliable process of moisture determination based on electrical properties, we required to know the absolute moisture content of the powders we were testing. The only available method was that of distillation with entrainers (3), which we found unsatisfactory with moisture contents below 0.5 per cent. and which requires constant attention over a period of one to two hours: even then, unless a trained operator is carrying out the test, it is quite unreliable. We were never able to guarantee results to an accuracy of more than ± 0.1 per cent.

For this reason the Karl Fischer process was tried and proved well suited to the problem. The method depends on the fact that iodine does not undergo reaction with sulphur dioxide in the absence of water. As soon as water is added the normal type oxidation-reduction reaction occurs:—

$$I_2 + SO_2 + 2H_2O \longrightarrow H_2SO_4 + 2HI$$

Pyridine is used as vehicle for the reagents and plays a part in the reaction, but the exact reaction mechanism is not yet clear. The reaction is certainly not stoichiometric as required by the above equation. However, the important fact from a practical point of view is that reproducible reactions do occur so that the iodine solution can be used in an empirical way. The Karl Fischer reagent is rather difficult to prepare and will probably be sold ready made in the near future as its use is better appreciated. For the benefit of those who would like to prepare their own reagent details are given below.

The chief development recorded in this paper lies in the method used for detecting the end point. Karl Fischer used a visual end point, but this is out of the question with coloured moulding powders, although in certain specific cases it can be used. The first development of the method was the introduction of the potentiometric end point (4). This is based on the fact that a pair of polished platinum electrodes immersed in the reagent solution develop a polarization e.m.f. when current is forced across them under certain conditions, whilst under other conditions the polarization is reduced by the depolarizing ions present in the solution, and may fall almost to zero. Such a change in conditions occurs at the end point of the Karl Fischer titration. Consider, for example, the solution which contains an excess of the Fischer reagent. We have iodide and iodine present, the former depolarizing

the anode, the latter the cathode, so that current can flow freely and the p.d. registered at the electrodes will be simply that due to the ohmic resistance of the solution. As we pass the end point and all the iodine is removed, it is clear that the cathode will develop a polarization e.m.f. and the electrode p.d. suddenly jumps. The change was, in our experiments, of the order of 20 millivolts and could be used to detect the end point. It was, however, rejected in favour of the method of Faulk and Bowden (5), which uses the so-called "dead stop end point."

The various methods of following the changes in current flowing across the electrodes when a small e.m.f. (about 10 millivolts) is applied to them have been developed (6, 7). Some of these (10) use sensitive galvanometers (24 divs. per micro-amp.), others electronic devices for amplifying the current changes (8). In all cases the current flowing seems to have been of the order of five micro-amps. In the apparatus to be described a much higher current value is used, namely, 100 microamps, and the end point is given quite sharply by a micro-ammeter reading 0-200 microamps. The applied potential is again of the order of 10 millivolts. It was found, using this higher current, that good readings could be obtained by direct titration of the water-containing solution with the reagent. The technique is described below in the experimental part.

It is essential for the success of the method to choose the right liquid with which to extract the moisture from the powder. It is advisable with thermoplastic powder to keep the temperature down below 90 degrees C., since otherwise the granules fuse together and the extraction is lengthened. Ethyl alcohol (b.p. 78 degrees) would seem first choice, but consideration will show that this is unsatisfactory because of the formation of a low-boiling azeotrope, which might result in appreciable loss of water. The use of solvents for the plastics concerned might again seem useful, but in our experience it is better to use a non-solvent in order to keep the viscosity of the liquid down. For this reason methyl alcohol was chosen as the extraction liquid, and, with one or two exceptions, such as polyvinyl acetal, which is rather soluble and gives a viscous solution, is suitable for all the common moulding powders. The low b.p. (64 degrees) and non-formation of an azeotrope with water ensure practically complete retention of the extracted water. We realize, however, that other extraction liquids may prove of value, and we believe that there is a real need for a more precise analysis of the theory of extraction of liquids from porous solids.

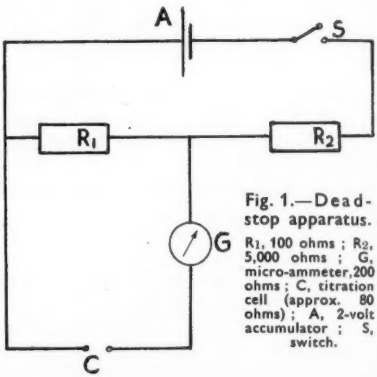

Fig. 1.—Dead-stop apparatus. R_1, 100 ohms; R_2, 5,000 ohms; G, micro-ammeter, 200 ohms; C, titration cell (approx. 80 ohms); A, 2-volt accumulator; S, switch.

The methyl alcohol suffers from the disadvantage of very great hygroscopicity so that titrations must be performed rapidly and technique must be consistent.

Using "Analar" pyridine for the preparation of the reagent, the titrations prove decidedly expensive. It is possible to recover the pyridine, but very inconvenient. We have used reagent prepared from technical pyridine with success provided that it was first dehydrated by distillation with benzene to remove the water. Drying the pyridine over potassium hydroxide was not found so efficient. It must, however, be pointed out that the quality of technical pyridine varies considerably. Laboratories not well equipped for solvent purification

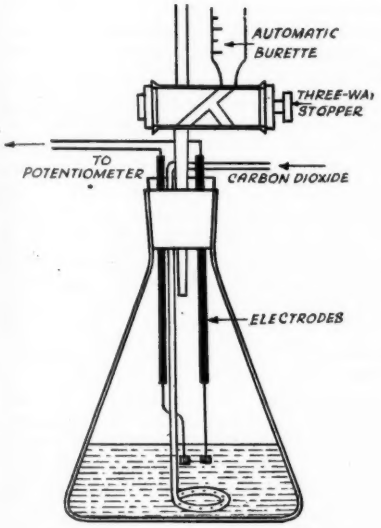

Fig. 2.—The titration assembly.

should always use analytical reagent quality, which should be dehydrated before use by adding 1 per cent. of benzene and fractionating until the temperature reaches 114 degrees C.

Experimental Details

Apparatus. The Karl Fischer reagent was dispensed from an all-glass automatic burette, capacity 50 ml. and with a 500 ml. reservoir, protected from moisture by a soda-lime packed guard tube.

Titrations were carried out in 100 ml. "Quickfit" conical flasks (B24 neck) fitted with a polyethylene stopper drilled to take the two electrodes, a gas bubbler tube and a hole for the reagent burette tip. Mechanical stirring was not used. It was found that either swirling the flask gently or passing a stream of dry carbon dioxide was satisfactory. The reagent is so sensitive that the stirring gas, if used, must be very thoroughly dried by passing through calcium chloride and phosphorus pentoxide.

The dead-stop apparatus is shown diagrammatically in Fig. 1. It will be seen that the current in R2 is approx. $\frac{2 \times 10^6}{5{,}000} = 400$ microamps whilst that in the cell C is approx. $\frac{100}{430} \times 400 = 100$ microamps. When C becomes polarized, however, its effective resistance becomes infinite and the current in the galvanometer drops to zero.

Reagents. Fischer reagent 700 ml. dry pyridine was measured into a 1,000 ml. conical and tared on a balance. Sulphur dioxide gas from a cylinder was passed in until 380 gms. had been added. After cooling to room temperature, 1 litre of pyridine, 200 ml. anhydrous methanol and 500 gm. of A.R. iodine were added. The solution was immediately cooled by holding the flask under the cold-water tap. Otherwise the reaction became unduly violent. The reagent was stored in a glass-stoppered bottle. Reagent prepared in this way has a water equivalence of approx. 0.006 gms. water per ml. The stability depends very much on the care taken in exclusion of moisture during preparation and also on the quality of the pyridine. Standardization of the Fischer reagent was carried out using

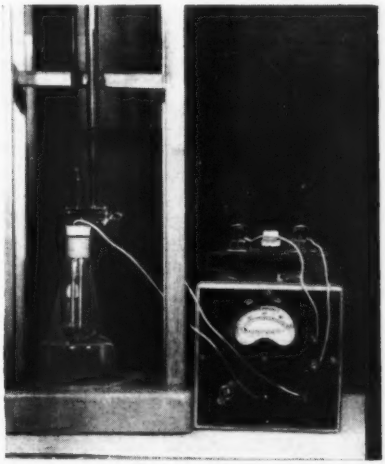

Fig. 3.—Titration assembly showing 2-volt accumulator and electrodes.

"Analar" citric acid ($C_6H_8O_7$, H_2O = 210.44), a weighed sample of which was dissolved in methanol which had been taken to the anhydrous point by adding a small quantity of reagent. A direct equivalence was thereby easily established. (For details of titration see below.)

Anhydrous Methanol. Commercial methyl alcohol was fractionated through a 150 cm. "Quickfit" column packed with glass helices. A product containing only 0.05 per cent. water was obtained in a single distillation. Further purification (from aldehyde, etc.) is not necessary since it has already been shown that the reaction is not influenced by the majority of organic unsaturated compounds (9).

Method of Titration

A suitable sample of the moulding powder, that is, one containing approximately 0.060 gm. water, was weighed to an accuracy of ± 0.2 per cent. (i.e., 5.00 gm. would be weighed to ± 0.01 gm.). In the case of powders which have been completely dried it is necessary to carry out this operation, in a closed weighing bottle, very rapidly, as experiments have shown that the initial rate of moisture absorption in a damp atmosphere may be very high, and the moisture content may increase appreciably in two minutes. Meanwhile 20 ml. of anhydrous methanol were placed in the 100 ml. conical flask, the electrode assembly put into position and the Fischer reagent added dropwise with gentle swirling. As each drop of reagent was added the galvanometer made a temporary surge and as soon as the first drop in excess was present the pointer moved over to 90 microamps, remained stationary for a few seconds and then gradually crept back to zero as moisture was absorbed from the air. If dry carbon dioxide was used as stirring agent the speed of this return of end point was reduced, but in any case it was necessary to work rapidly at any time when the solution was in contact with air. The flask was now taken from the burette, the stopper removed and the moulding powder added. Without waiting, a dry Leibig condenser fitted at the open end with a soda-lime guard tube was attached and the methanol boiled gently for 30 mins. The apparatus was then removed from the hot plate, the flask cooled in running water, the condenser and the electrode assembly placed in position. Fischer reagent was added slowly with constant swirling, until a permanent galvanometer reading was obtained. By this procedure the need for a blank determination on the methanol was eliminated, a preliminary test run showing a moisture pick up of less than 0.05 c.c. of the reagent.

For standardizing the reagent the procedure is exactly the same, except that, citric acid being readily soluble in methyl alcohol, the boiling can be omitted and the solution titrated directly.

Experimental Results

We found that the reagent decreases in strength by about 2 per cent. in the first week and thereafter more slowly, provided pure pyridine is used. (See Table 1.) It is advisable to standardize daily.

A consideration of the above figures will show that, working on the assumption that titrations were accurate to ± 0.05 c.c., the maximum precision

Table 1.—Standardization of the Karl Fischer Reagent.

Sample	No.	Date	Wt. of citric acid taken, gm.	Vol. reagent, c.c.	H_2O mgm./c.c.
A	1	22 . 10 . 45	0.896	10.80	7.12
	2	22 . 10 . 45	0.9216	11.20	7.08 (Mean 7.10)
B	1	27 . 10 . 45	0.7458	8.10	7.95
	2	27 . 10 . 45	0.8202	8.90	7.92 (Mean 7.935)

Table 2.—Determination of Moisture in Standard Plastic Moulding Powders.

No.	Material	Wt. of sample, gm.	Volume of Fischer reagent, c.c.	% H_2O found	Mean value
1	Urea formaldehyde moulding powder	1.000	14.55	11.64	11.65
		1.000	14.55	11.64	
		1.000	14.60	11.68	
2	Phenol formaldehyde moulding powder	3.00	18.20	4.853	4.84
		3.00	18.10	4.827	
3	High acetyl cellulose acetate. Sample A (Green)	2.090	4.60	1.810	1.805
		2.000	4.40	1.800	
4	High acetyl cellulose acetate. Sample B (Red)	5.00	9.80	1.568	1.564
		5.00	9.75	1.560	
5	High acetyl cellulose acetate. Sample C (Red)	5.00	9.75	1.560	1.568
		5.00	9.85	1.576	
6	Cellulose acetate dried at 60°C.	5.00	1.50	0.240	0.248
		5.00	1.55	0.248	
		5.00	1.60	0.256	
7	Alvar moulding powder	5.00	11.35	1.816	1.812
		5.00	11.30	1.808	

obtainable varied from ± 3 per cent. of the actual value in No. 6 to ± 0.27 per cent. in No. 2. The experimental results show deviations of this order and suggest that provided a suitable weight of powder is chosen for analysis, a precision of ± 0.5 per cent. of the actual moisture content is easily obtainable. Thus, for example, with No. 6 it would be necessary to use 50 gm. powder to give a burette reading of 15 c.c.s, giving a precision of ± 0.3 per cent. Actually, at a moisture content of 0.25 per cent., all that is necessary for factory control is a precision of ± 0.01 per cent. or ± 4 per cent. of the actual figure, so that our 5.0 gm. sample is satisfactory. With such a small test sample, the actual technique of sampling is important and at least 500 gm. should be taken, well mixed and an aliquot weighed out. Duplicate titrations should be within the limits indicated above.

For comparison purposes, the sample of high acetyl cellulose acetate No. 3 was analysed by the entrainer distillation method. This gave an average figure of 1.6 per cent., but the deviations between consecutive readings were considerable —up to 0.5 per cent. The precision obtainable with these moulding powders is comparable with that of Carter and Williamson (10) who applied the method to synthetic resin solutions.

Summary

The Karl Fischer method has been successfully used for the determination of moisture in plastic moulding powders. The precision of the method is of the order of ± 0.5 per cent. of the moisture present. In the absence of really reliable alternative methods it was not possible to assess the accuracy, but as a standard control test the process is quite reliable.

The author expresses his thanks to Halex, Ltd., on whose behalf the work was carried out, for permission to publish this paper.

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Planned Mould Maintenance Service Aids Economical Production

Section XVIII

By W. M. HALLIDAY

In numerous injection moulding requirements, where the article has to be moulded with a number of identically sized pre-formed inserts, it is often highly economical to incorporate fully automatic sorting, selecting, or feeding arrangements for supplying the inserts to their respective positions in the mould cavities.

In this present section, therefore, it is proposed to describe and illustrate several very interesting typical feeding mechanisms, for ensuring such fully automatic selection and delivery.

Special emphasis will be given throughout the section to those features likely to prove of most interest and guidance to both mould designer, tool engineer and maintenance man, particularly noting the various desirable and undesirable mechanical and operating features.

In many of the examples given it will be observed that the feeding or sorting devices are built directly into the normal mould construction, being actuated, moreover, by the usual motions of the mould blocks. Some illustrations will also be given of automatic feeding devices operated by external means such as air cylinders, etc.

Some devices will also be illustrated to show how simple gravity feeds may be incorporated so as to achieve extreme simplicity of mould design, smaller number of working members, smoother operation, and longer working life to the moulds.

AS was intimated in the closing paragraphs of the preceding section 17 which appeared in the January issue of "Plastics," it has now become advisable to give some attention to the consideration of the design, construction, operation and maintenance problems, etc., associated with the utilization of purely automatic sorting and feeding devices for delivering inserts correctly, in contrast to the problems noticed in connection with hand-feeding arrangements dealt with in previous sections.

Two forms of automatic feeding of inserts are in use at the present time. The first and by far the most commonly adopted method employs gravity as the motive power for the movement of the insert components through the feeding device. The other method embraces purely mechanical force for such movements. Of course, in some mould constructions it is possible to employ a combination of both methods, such as in the following manner.

The insert parts can first be fed down a suitably inclined chute or magazine track, by their own weight, being caused to drop, roll, or slide into a power-operated rotating or reciprocating drum which then is mechanically actuated in order to bring the inserts into their proper stations in the mould.

In actual practice, by using one or other of these methods extremely interesting and ingenious sorting, feeding, and locating devices can be arranged which greatly step up output by reducing the uneconomic loading times previously absorbed by hand sorting or loading of the inserts.

At the outset of this discussion it must, of course, be fully appreciated that often it will hardly be feasible to the mould designer to adopt automatic feeding of inserts, either by gravity or mechanical means, because of a variety of reasons, some of which touch upon difficulties of mould construction and adaptation for such feeding facilities, and some of which centre around initial costs and mould charges generally.

The author feels that these determining considerations very often do not receive the attention they deserve, with the result that an excessively expensive and complicated mould design may be put into

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manufacture with added initial cost, and probable unduly severe maintenance charges when the mould eventually is put into production. Or, on the other hand, the method of feeding may not be suitable for the type of insert, with the result that production instead of being increased or facilitated is actually retarded. Because of the relevancy of these several factors, therefore, a short list is appended in the hope that some guidance will be afforded to designers and mould engineers, especially throughout the preliminary stages of a mould design when it is essential that the problems of feeding methods for inserts, and their probable cost and benefits shall be reliably determined. These factors in their order of importance are:—

1. Suitability of Insert Component

Where the matter of automatic feeding of an insert is suggested, the suitability of the component itself to such a method of delivery is one of the utmost importance, particularly during the projection stages of the mould design. Unless the shape and size of the insert itself conform to certain preferred forms and limits, it will prove difficult and expensive to provide for automatic gravity or purely mechanical feeding.

On the other hand, the peculiarities in shape of the insert may entail a very complicated type of feeding mechanism, which may prove not only highly expensive to the original outlay on mould, but may also mean a rate of output entirely uneconomical, due to slowness of production or repeated failure or breakdown of some part of the device.

The most satisfactory and readily adaptable shapes of insert component for such automatic feeding methods are, of course, truly cylindrical studs, screws, pins, and the like. These should preferably be parallel in diameters, although slight tapers for all or a portion of their lengths will not produce any insuperable feeding difficulties. Cylindrical tubes, or flat, square, or rectangular parts can also be dealt with quite easily.

The general rule to be borne in mind is, that in gravity feeding arrangements especially, the insert component must be capable of rolling readily down inclined guides, or falling freely through a chute, or sliding along a specified track.

If there are external projections on the insert likely to retard or prevent any of the above primary movements under its own weight, then the designer will most certainly encounter difficulties, unless the shape is such as will permit movement by purely mechanical means.

Parts which are threaded for the whole of their length may also give trouble, although at first sight it would appear their rolling down a chute is a perfectly simple matter. The difficulty with moving such parts is that as they roll down a chute they tend to mesh together with their threaded portions, which causes an endwise displacement of some members, sufficient to jam these against the side of the chute, and, as a result, stoppage in feed occurs.

Inserts of complicated or uneven external shape very often give rise to similar troubles owing to their poor sliding, rolling, or tracking capacities, and in moulding operations few things prove more irritating and time wasting than an injection mould equipped with automatic feeding devices which do not function effectively, or involve constant maintenance supervision in the shape of cleaning, adjusting, and clearing of jammed components.

Very often, however, a type of insert totally unsuited to the gravity method of feeding may be handled quite efficiently by a simple mechanical feeding device, always provided that the ease of production and rate of delivery of the inserts to the mould cavity are such as not to slow down the output of finished mouldings, which point, of course, will have to be decided by the designer.

Very often there is involved use of a feeding mechanism of complicated design, which, in turn, usually means greater care throughout its operation, and the probable greater measure of maintenance

oversight and service to maintain the feeding device in sound working condition. The mould designer, when laying down the essential features of any projected mould design, will, therefore, have to balance up very carefully the benefits and disadvantages which are to be derived from use of such a type of insert feed.

2. Sorting Out Inserts for Delivery in Specified Manner

Another equally important factor which is often overlooked relates to the effective sorting out of the inserts immediately prior to passage through the feeding portions of the automatic feeding mechanism.

As readers will be well aware, the common practice when using insert pieces of nearly every kind is to provide on the insert itself additional keying facilities in the shape of slots, flats, grooves, diamond knurling, or raised pins, etc., which portions eventually become surrounded with plastic material during injection stages. By this simple means the moulded-in insert pin, etc., is precluded from endwise or rotational movement.

The keying or locking provisions effected upon the insert mean that the part must always be delivered to the mould cavity in a certain way so that the treated portion is always resident within the cavity area and so can become surrounded with plastic material.

Obviously, with such needs as these any automatic feeding device built into the injection mould must also include provisions for rapidly and unfailingly sorting out the components immediately prior to their entry into the feeding channel. Such sorting arrangements will have to be most sure and foolproof in their functions, otherwise very serious troubles will be caused, such as delayed production and the manufacture of excessive scrap, due to the inserts being wrongly positioned.

Naturally, the greatest benefits from the use of automatic gravity or mechanical feeding will be gained when the operator can place a large quantity of insert parts into a suitably located container regardless of their shape or the manner in which they have to be admitted into the mould cavity area, reliance for sorting being left to the device itself.

Indeed, the writer has found in actual practice that the biggest difficulties arise precisely in connection with the design of effective sorting facilities in conjunction with automatic feeding arrangements on moulds.

3. Size of Insert as a Feeding Factor

Next, it is often found that the size of an insert has a very important bearing upon the availability or choice of feeding method and device to be employed, and in this connection again it is urged that close study be given whilst the mould design is in its elementary stages.

If, for example, an insert is of very large overall dimensions, the inclusion of the necessary sorting and feeding arrangings may cause an unwarranted addition to the initial mould costs; or, on the other hand, may make its working when installed so slow or unbalanced as seriously to reduce production. Yet again, the passage of such large articles may involve the maintenance engineer in a totally disproportionate maintenance oversight in order to maintain production at an economic level.

For these reasons then, it will always be advisable to select purely mechanical feeding methods for large insert components rather than gravity means, and, of course, where the necessary feeding equipment is likely to make the mould costs too large, hand sorting and feeding by detachable magazine plate of the type previously illustrated should be selected.

Very small inserts may also produce unsuspected difficulties when fed by automatic means unless the requisite mechanism is constructed with precision and to close limits of fit. The troubles otherwise will arise from the small inserts finding lodgment in interstices and crevices in the feed chutes or other parts of mechanism, thereby causing an interference with the ready delivery of the parts.

4. Design of Feeding Mechanism

This is a vitally important factor when considering the functioning and working life of the mould construction generally. Only the simplest designs should be selected, whilst the number of working parts should be kept as low as practicable. Intricate timing movements should also be avoided. All these features, if adopted, would probably give rise to increased maintenance service. Indeed, care will always have to be taken lest the design of feeding device is of such a complicated character in comparison with the rest of mould construction as leads to operating troubles and reduced output.

On the other hand, the engineer will constantly need to be on guard against the development of makeshift feeding arrangements installed after the moulds have been constructed.

Considerable time and energy may be wasted by such installations, and if space permitted the author could give examples of still more serious troubles of the following nature. Unless the feeding or sorting mechanism is correctly designed and intelligently fashioned according to well-established mechanical principles, it may be found that after a period of operation of the mould, this latter member may have suffered some damage due to the unsuitability of the feeder for the inserts. Economy will not be achieved if a very low cost insert feeding device is set up only to find after a short time that costly injury has been effected by it to some equally important member of the mould, whose correction entails protracted attentions from the maintenance engineer.

5. Method of Operating the Feeding Mechanism

Again wherever possible the selected type of feeding or sorting arrangements should be operated from the normal opening or closing motions of the mould blocks, or machine platens, rather than from outside sources of power, such as pneumatic cylinders, power drive from electric motor, or spring-operated appliances.

All the illustrated examples of such mould feeders which will subsequently be given are of mechanisms operated from the motions of the mould blocks themselves. From these it will be seen that very wide possibilities of design forms are open to the designer without having to introduce extraneous power drives, etc.

The advantages of such designs are several, chiefly: The mould becomes a self-contained unit capable of simpler construction, and simpler setting-up or removal from the machine platens. It is one also free from the risks of failure associated with such extra forms of power drive as motors or compressed-air supplies.

There is one important point to be considered, however, when the designer is engaged in selecting the best form of drive for the insert feeding apparatus. Sometimes it occurs that the force required to operate the feeding mechanism attached to the injection mould is far more than is required to operate the mould itself, as a result of which too great a load may be imposed upon some mould member, or upon the machine platens and their operating mechanism. Where this obtains and is allowed to persist it may be found that mould members thus subjected to heavy strains become stressed and perhaps fracture.

Cases have occurred where a mould could not be completely closed due to the greatly additional pressure required at the instant of final closure for operating the feeding device for the inserts, with the result that heavily flashed mouldings have resulted.

6. Safety Provisions

In far too many instances where an injection mould design incorporates a gravity or mechanically actuated insert feeding device, scant attention is given to the question of its safe, fool-proof functioning.

Consideration must be given to the possibility of leakage or escape of plastic material along the insert feeding chutes or guides, etc. Particularly must provisions be made to prevent the making of

a "shot" without all the insert components being in position. Thus all such feeding mechanisms must possess some safe interlocking measure.

Push pins required for ejecting the inserts from the magazine tube into the mould cavity should be exactly the same shape and size as that of the insert itself so that in the event of an insert being omitted the push pin will effectively seal off entry of material into feeding tube.

Examples will be given later of such interlocking arrangements which have been found useful and reliable in practice.

7. Lubrication and Cleanliness

One other factor which can be mentioned here concerns the questions of mould cleanliness and lubrication. In normal moulding practice it is usual for the moulder to receive the pre-machined inserts as a "free issue" from the purchaser. This means that the questions of packing, and transport, are not under the plastic moulder's control as a result of which very often the inserts arrive packed in dirty containers, or bags, and have machining swarf, cuttings, coolant, etc., freely smeared over them.

Unless all this extraneous material is cleaned off, trouble may ensue because its admission into the feeding tubes affixed to the mould may speedily lead to trapping, or seizure of the timing or feeding mechanism.

For this reason the feeding mechanism should be so constructed and built upon the main mould blocks as will permit easy dismantling and removal of essential parts. This will greatly facilitate regularized cleaning operations, when the tubes can be cleared of all accumulated dirt, etc., and be given liberal lubricant at essential points. This may appear a somewhat minor point, but a little attention bestowed on simple arrangements will be amply repaid as the present writer can testify.

In order to resist wear of vital parts important components connected with the automatic feeding mechanism must also be hardened and surfaced ground as in the case of mould members proper, and provision should also be made for effective lubrication of same.

We come now to the consideration of a number of more general factors associated with the preparation of the inserts themselves which have an important effect upon the design, type of construction, operation and maintenance needs of the automatic feeding device to be installed, and it is well worth while giving a little attention to them.

Dimensional Uniformity of Insert Components

Where insert parts are automatically fed to the mould cavity area either by gravity or purely mechanical means, it is vitally important that the overall dimensions of each component shall be uniform with its predecessor. In the case of hand feeding of inserts, this, of course, is not so important because any oversize piece would be immediately detected by the operator's inability to insert it into its holding seat, and hence no damage or hold-up would ensue.

Not so in the case of inserts fed automatically, since an oversize part might become locked within the feed tube itself, thereby arresting the flow of inserts. Or again the mechanism might be strong enough to eject the insert clear of the feeding tubes, but only to jam it too forcibly into its locating seat in the mould block with resultant damage to that member at a point immediately surrounding the location.

On the other hand suppose an undersize insert is accidentally placed in the automatic feeder there will be the risk of trouble due to flashing of material along the feed tube which in turn will tend to bind the subsequent flow of parts and entail frequent removal of the tubes for cleaning purposes. And it should be noted that this is quite additional to the undesirable extra flash which would be formed along the sides of such an undersized component.

Therefore it is of particular importance that the dimensions of inserts especially across their cross section and lengths

should be maintained within close limits where they are to be fed in automatic feeding devices.

Diameters should be maintained on such pre-machined parts to within plus or minus .0015 of the nominal size. Wherever possible the exterior of such parts or the largest diametered portions likely, to make contact with the walls of feeding magazine or tube should be smoothly polished so as to reduce to a minimum the frictional contact.

Length dimensions also should be maintained within reasonably close limits, say, of not varying more than plus or minus .005 in. It should be remembered that, in many feeding arrangements, the length of the component is utilized for correctly guiding it down the feed tube or chute, hence variations should be as small as possible.

Where the inserts are supplied to the moulder by an outside source it will be found advisable to have a clause in the contract terms covering the above matters of permissible dimensional tolerance, because, with the moulding engineer thus making his requirements perfectly clear, there will be much less likelihood of trouble and production delays being occasioned by the use of unsuitable or non-uniform insert components.

Threaded Insert Components

Mention has already been made of the interlocking tendencies possessed by threaded components when fed automatically down gravity or power-operated chutes. This is usually only the case where the inserts are threaded on the largest diametered portion, since these portions tend to foul each other as the parts roll down the chute. This not only tends to retard the smooth flow of the parts into the mould area seatings, but raises other objections as follow:—

Where such threaded insert pieces have become interlocked on their threaded portions, some means will have to be installed in the feeding or sorting mechanism for displacing each insert sideways from its intimately associated companion before that component can be pushed through into its correct mould-block seating. Such sideways displacement must, however, only be effected to one insert part at a time, and, moreover, it must be performed in such a manner as will not damage the threads of each part in contact, or drastically alter the axial position of the succeeding component as will make its insertion into the mould seating difficult.

To avoid all such troubles, therefore, the designer should try to arrange for the threaded portions on automatically fed inserts to be located on other than the largest diameters.

Another important point to be observed relates to the possibility of damaging the run-out feather edge of the screw threads. The push pins of the sorting or feeding device must be so arranged as to avoid inflicting damage to the leading thread on the insert.

A further point worthy of note in connection with screw-shank inserts is that when the insert is correctly in position in its seating hole there should be a short parallel unscrewed portion of its shank within the feed tube. Unless this is arranged there will be a danger of plastic material being forced along the screw threads and thence into the feed tube of the device, or to some equally vital operating members. Thus the free flow of insert components may become impeded, or completely arrested. The author could give numerous practical examples of difficulties of this kind and of the protracted and expensive corrective measures required in respect of the automatic feeding mechanism in order to overcome such troubles. Usually those difficulties might have been entirely avoided given closer attention to the above point when initially designing the automatic feed.

Threaded insert components also tend to accumulate to a far greater degree machining chips, and residues along their threaded portions than is the case with plain inserts. For this reason it is advisable that all such inserts be carefully washed and checked before admission to

feeding mechanism, otherwise troubles will surely arise due to chips and particles of dirt being shaken off the insert so as to fall and lodge in vital parts of the working mechanism. Should this trouble occur very frequent stoppage and dismantling of the feeding gear will be entailed. In general, all types of inserts should be well cleaned before admitting them to the mould, but especially is this required in the case of threaded parts which are to be fed by a complicated automatic device. It should also be borne in mind that serious breakdown of some essential working member of the feeding gear may result from this same cause. More will be mentioned later about the need for and ways to accomplish inexpensively the suitable degree of cleanliness of all insert parts.

Weight of Inserts

Here, again, another very important factor arises in cases where automatic feeding of inserts to mould locations is contemplated. It is very easy to overlook this point completely, only to find that too great a weight of inserts has been permitted to enable free or productive operation of the moulds.

In practically every case of automatic insert feeding the mechanism includes a suitably shaped and sized container, generally attached to one of the mould blocks, or on a superstructure fixed to this member. A convenient quantity of insert parts is then placed, perhaps indiscriminately, into this container, and are subsequently fed down a magazine track or chute or tube to their required location in the mould block.

A little consideration will show that too large a weight of inserts housed within the container and chute may easily produce such an additional load upon the mould blocks as to impede very drastically their free working, and so at the best serve to slow down production unduly, and at the worst even impose such strains upon the mould blocks or other members as will lead to fracture. Naturally, the greatest risks of such occurrences will centre around instances where multi-impression moulds are being automatically fed, and, in such cases, the author strongly recommends the designer to pay especial care and attention to the question of weight of inserts to be dealt with.

Method of Retaining Insert

In those cases where the mould designer is afforded some say as to the choice of means for preventing the insert component from rotating or pulling out of the finished moulding, considerable convenience and assistance will be given him in the matter of the design and operation of the automatic feeding arrangements to be installed on the mould.

In numerous ways he will be able to fashion keying or locking facilities on the insert shank in different forms the better to suit the method of feeding and functioning of the device, thereby eliminating at the outset of mould design a number of possible drawbacks and operating difficulties. Furthermore, he will also be assisted in selecting the strongest type of insert form which will be free from liability to distortion or bending or jamming when being actually processed through the automatic feeding mechanism.

To take one simple illustration which constantly arises. This consists of a cylindrical insert piece having its largest diametered portion externally diamond knurled. Troubles will almost certainly arise if these parts have to be fed down fairly close-fitting tubes, since it is notoriously difficult for a machinist to maintain close-limit dimensions on such knurled diameters. Excessive size variations and consequent danger of jamming are thus apt to develop. But where the designer is allowed a little latitude on the design of insert also, generally he will be able to make simple modifying suggestions which will eliminate the feeding troubles mentioned.

Similar troubles due to jamming or breakage of mechanism are prone to occur in those cases where an insert has been excessively weakened at certain points by the form of staking employed. Inserts of this kind will produce the greatest difficulties at the point when the

automatic feeder push pins are actuated to press the inserts into their mould-block locations. If they are unduly slender at one point there will be additional tendency towards buckling and jamming in the entrance to the block seat.

Headed type of inserts may present some obstacles to the mould designer when having to fashion a feeding mechanism, since such components do not lend themselves to easy rolling, sliding, or operating. Here again it may often be found that elimination of the head portion required for staking into the moulded article, in favour of a slight undercut, will dissolve a number of awkward snags and render possible the use of a more simple type of automatic feeding mechanism.

On this aspect of insert usage generally it must be appreciated that considerably more care is required both in respect to the design, construction, and manufacture of inserts to be fed by purely automatic means than in those which have to be delivered to the mould block by hand. Also the mould designer should be given a greater say over the form and dimensions of the insert to be used in conjunction with this means of feeding than with other types for the reasons just explained above.

If this is secured, other things being equal, it will be more easily practicable for the design to develop a satisfactory automatic feed which will not only maintain a high level of production, and ensure accurate location of the inserts, but will also greatly reduce the possibilities of serious breakdown or mechanical failure of some part or the whole of the feeding mechanism.

Method of Operating Feeding Mechanism

Various means are employed for operating insert feeding mechanisms, and it is hoped in the succeeding pages to present illustrations of a number of highly practical and valuable designs which will indicate not only the diverse mechanical methods which can be used; but also, and this is equally important, the ways in which conventional mould block constructions can be adapted in order to incorporate economical automatic feeding devices.

Broadly, two main types of such feeding devices are in widespread use, these being distinguished in the following manner:—

(1) Fully automatic insert feeding arrangements in which the components to be moulded-in are caused to pass through the device and into their appropriate station in readiness for moulding by means of their own weight. This is the gravity-operated kind of device. Needless to mention, this type is perhaps more extensively employed than the other.

(2) Fully automatic mould insert feeding mechanisms in which all the requisite movements of the insert are performed by purely mechanical means.

The first type of mechanism generally permits a much simpler construction and operational sequence, and it will also be well appreciated it is one best suited for those inserts whose external shape is such as readily combines with easy rolling or sliding movements.

The second type is again divisible into two distinct kinds, i.e., those constructions in which all the necessary power for the operation of the feeding device is derived from the normal movements of the main mould blocks, or from that of the movable machine platen to which the block is attached; and those mechanisms which rely upon an outside source of power such as compressed air in the form of pneumatic cylinders attached to the feeding device in such a manner as to permit driving the requisite parts. Hydraulic power is also sometimes used in a similar manner.

Here, again, generally much simpler arrangements can be fashioned on the first-mentioned form than when an externally located source of power is utilized.

Usually where motions are obtained from compressed-air cylinders or hydraulic ditto, a somewhat elaborate system of valves and timing devices is required so as to obtain correct synchronization with the cycle of movements

of the mould blocks. As will be understood, such a system of valving, etc., will entail some additional oversight and maintenance attention.

Before commencing to illustrate and discuss the constructional and design features of these various forms of automatic feeding, it should be remembered that with all these types it is generally necessary to employ a selecting or sorting mechanism.

Sorting Out of Inserts

Most inserts have to be presented to the mould cavity location in a certain manner, and thus it will be essential that each piece be correctly sorted out before or immediately after passing through the automatic feeding. Usually it is precisely in connection with this need that the mould designer will have to display his mechanical ingenuity most in order to ensure fool-proof delivery of such parts.

This aspect of design will be specially emphasized in the ensuing sections dealing with practical examples of some typical automatic feeds. Simple constructions have been selected again because of their relative higher efficiency and low maintenance service required.

In the succeeding portion of this section, therefore, the author will describe a number of highly interesting mechanisms arranged for automatic feeding of inserts either by means of gravity, or operated from normal mould block motions, or by external means, with especial attention being given to the various design and constructional features to be selected in order to ensure the maximum operating service, and the least amount of maintenance oversight.

SILICONE RESINS

WHILE we have known for some considerable time that British Thomson-Houston Co., Ltd., has been carrying out research work on the Silicone resins, the first official announcement regarding this fact has just been published by the company in a circular entitled "Notes on the work of the B.T.H. Research Laboratory in 1945." This circular includes the following information:—

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London Wholesalers require for home market plastic household goods, including egg-cups, beakers, cups, saucers, ashtrays, etc. Box 8882, care of "Plastics." 106-x6173

MACHINERY, TOOLS AND PLANT

2,000-ton down-stroke hydraulic press by John Shaw, 30-in. ram, 18-in. stroke; table 42 ins. by 26 ins.; 5 ft. daylight.

Several 635-ton hydraulic presses, ram 18 ins. dia. by 4 ft. 6 ins. stroke; table 6 ft. by 4 ft.; daylight about 5 ft. 6 ins.; four 7-in. columns.

Several 400-ton hydraulic presses by Greenwood and Batley, 16-in. ram, 2-ft. stroke; table 3 ft. by 1 ft. 5½ ins.; daylight 4 ft.; cast steel cylinders.

Several 300/350-ton upstroke hydraulic presses, 2-column type, ram 26-in. dia. by 36-in. stroke; daylight approx 3 ft.

200-ton vertical upstroke, 4-column hydraulic press by Rose, Downs and Thompson, table 2 ft. 9 ins. by 1 ft. 6 ins.; daylight approx. 3 ft.

New 40-ton hydraulic Bakelite moulding presses, 10-in. stroke, table 11 ins. by 16 ins.; can be arranged with adjustable daylight. Early delivery.

Hydraulic pump by Fielding and Platt, belt driven, vertical gear, 3-throw type; steel rams 3¼-in. dia. capacity 25 gallons per minute; 1,120 lb. per sq. in. working pressure.

Motor-driven high-speed oil hydraulic pump by Fielding and Platt, type H3 (TH66) No. 9230; 10 gallons per minute at 2-tons per sq. in. working pressure with 40 h.p. standard voltage a.c. motor.

Horizontal motor-driven variable-stroke pump by Bradley and Turton, ram ⅜-in. by 2-in. stroke; capacity 1 gallon per minute at 1 ton per sq. in. working pressure; driven by 4 h.p. new Brook motor with starter.

George Cohen Sons and Co., Ltd., Wood Lane, London, W.12; and Stanningley, near Leeds. 105-17

One M.S. Enclosed Receiver Tank, 26 ft. long, 5 ft. 6 ins. dia., made from ⅜-in. plate; double riveted; price £150.

One horizontal M.S. jacketed vessel with stirring gear, 12 ft. long, 5 ft. dia., made from ⅜-in. plate; price £225.

Two vertical C.I. enclosed mixing vessels, 36 ins. dia., 45 ins. deep, radial arm type agitators on vertical shaft; driven through bevel reduction gearing by camshaft with fast and loose pulleys, side feed hopper and bottom outlets 12 ins. by 8 ins. to be in good working condition; £95 each.

One horizontal chemical mixer with ⅜-in. thick antimonial lead barrel mounted on heavy C.I. rocker stands, with gunmetal shaft and agitators; driven by fast and loose pulleys; price £85.

Reynolds, Mann Place, Domestic Street, Leeds, 11. 107-5620

SITUATIONS VACANT

Technical Representative, with good personality and proved sales record, required by leading firm of plastics manufacturers for Scotland, must have sound knowledge of phenolic plastics, and preferably a good engineering background. Applications, giving full details of technical and sales experience, age, etc., should be addressed to Messrs. Birkbys, Ltd., Liversedge, Yorks. 107-5938

Research Chemist required, with high academic qualifications and experience with synthetic resins and allied products. Bibby and Baron, Ltd., Dumers Lane, Bury. 106-5939

Assistant Chemist required for works laboratory. Bibby and Baron, Ltd., Dumers Lane, Bury. 106-5940

Situations Vacant—*contd.*

Charge Hand and Setter required, permanent situation to right man, must be used to modern injection moulding machines. Apply, Injection Moulders, Ltd., Westmoreland Road, N.W.9. 105-20

Wanted for established factory in Palestine, technician with good up-to-date and practical experience of plastic moulding processes of all kinds. Box 9647, care of "Plastics." 105-x9570

Toolmakers, fully experienced, for the manufacture of moulds for the mass production of compression and injection moulded plastic articles, Home Counties now, South Wales later; good rates for highly skilled men. Write full details to Box 9566, care of "Plastics." 105-1

Plastic. Foreman for moulding shop required by engineering firm, capable of organizing and running new department, scope and excellent prospects for experienced man. Details of experience to Box 9563, care of "Plastics." 105-2

Plastic. Tool designer required by engineering firm to take charge of design and manufacture of tools for plastic mouldings, scope and excellent prospects for experienced man. Details of experience, etc., to Box 9564, care of "Plastics." 105-3

Technical Representative required. Applicants should have a knowledge of the plastics industry both from the technical and sales aspects. The product involved offers wide scope and interest; a knowledge of radio and electrical matters is desirable, but not essential. Excellent prospects for the right man. Write, giving details of experience, age and salary required. Radio Heaters, Wokingham, Berks. 105-23

Foreman required for night shift with London injection moulding concern, previous experience of American automatic machines essential; permanent position. Write, stating age and full particulars, to Box 9562, care of "Plastics." 105-4

Plastics Engineer required to control design and manufacture of tools, also to be responsible for the production of moulded products, only highly practical and technical applicants considered. State age, experience and salary required to Box 9561, care of "Plastics." 105-5

Mould and Diemakers required, first-class men only, with pre-war experience in the plastics field, very well equipped toolroom, North-west London district, good pay with excellent prospects in very attractive industry. State details and wages required. Box 9567, care of "Plastics." 105-9

Firm of manufacturers in Kent are desirous of getting into touch with a designer of injection moulds, as used in the rubber industry, to design for them a number of injection moulds in his spare time. Box 9557, care of "Plastics." 105-10

Leading firm of moulders require the services of a capable technician to take charge of tool design office. Applicants must provide full proof of service in the plastics industry, be fully up to date, and prepared to bring new and up-to-date ideas with them. Copies of recent references should be submitted. Write, stating age, particulars of experience and salary required, to Box 9556, care of "Plastics." 107-5944

Process Chemist for plastics factory in the Home Counties, familiar with compression and injection moulding and extrusion. Full particulars to Box 9565, care of "Plastics." 105-12

Manager required by a firm of manufacturers to take charge of their cake ornament and fancy goods department. Please apply, giving full particulars of experience, to Box 120, E. W. Barney, Ltd., 4 New Court, Clements Inn, W.C.2. 105-16

Large Swedish textile concern requires resident practical technical engineer, production American cloth, artificial leather and other plasticized fabrics. Period one year minimum, longer by agreement; good salary for right man; pleasant living conditions. Please reply immediately, stating experience, age, salary required. Box 9631, care of "Plastics." 105-x9465

A Plastic Technologist is required to assist in plastics development work for an important industrial organization in West London area. A knowledge of plant and methods used in manipulation of thermoplastics is desired. Applicants must have a good background of engineering experience, besides being familiar with the technology of manufacture and processing of thermoplastic materials. The post offers good prospects to a suitable man. Write, stating age, experience and qualifications, to Box 9680, care of "Plastics." 106-5964

Manufacturers of synthetic resin glues require experienced sales manager; progressive position for right man. Write, stating age, details of experience and salary required, to Box 9553, care of "Plastics." 105-14

Manufacturing Chemists specializing in the manufacture of wax products require working foreman, used to the control of labour. Box 8884, care of "Plastics." 105-x6172

Situations Vacant—*contd.*

Important Manufacturers of Plastics require the services of an efficient toolmaker; one used to making moulds for Injection moulding machines and Compression machines. Applicants must be able to develop blue prints on own initiative; only those with first-class experience need apply; good remuneration and prospects to the right man. Address inquiries to O. and M. Kleemann, Ltd., 17-20 Woodfield Road, Welwyn Garden City. 105-5287

Energetic young man with knowledge of trade, to build up plastic department in old-established company. Apply Box 8721, care of "Plastics." 105-5292

Manager, storekeeper and order clerk wanted for plastic and photographic material business. Lloyd's, 72 Bridge Street, Christchurch zzz-49

SITUATIONS WANTED

Man, age 36, 14 years' experience in plastics industry, practical and executive, desires situation, works manager or assistant works manager, must be progressive. Box 9698, care of "Plastics." 105-29

Artist with considerable mechanical design experience will undertake art work for catalogue or Press. Industrial design or stylising of all kinds. Reasonable terms. Box 9348, care of "Plastics." 105-x8017

Mechanical Designer (28), A.M.I.W., M.J.I.E., experience with moulds, jigs and tools, small intricate mechanisms, plant layout, conveyors, at present employed in the plastics industry as assistant to chief engineer, requires similar executive post, salary £550. Box 9324, care of "Plastics." 105-x7994

Advertiser, thoroughly experienced in business and factory organization, control of staff, purchasing plant, tools, chemicals, seeks situation as commercial manager, chief buyer or position where these qualities are called for, excellent references. Box 9609, care of "Plastics." 105-x9361

Draughtsman journeyman, experienced sheet metal and castings, desires drawing office situation to learn plastics mould design, fast, accurate worker; state salary offered. Box 9526, care of "Plastics." 105-x9103

Advertiser wishes contact plastic organization where three new patents could be exploited and salaried appointment provided, extensive experience administration, sales organization, staff control, salary not so important as prospects, small, live firm preferred. Box 9176, care of "Plastics." 105-x6877

Works Foreman of plastics plant, with knowledge of mould design, desires post with reputable firm anywhere. Would start new factory. Box 9459, care of "Plastics." 105-x8899

Works Manager of small plastics concern, free now to accept appointment with progressive firm; experienced in development work, used to work on own initiative. Box 9398, care of "Plastics." 105-x8140

Assistant Export Sales Manager of plastic moulding company seeks position in London; conversant with present-day export conditions, also knowledge of wholesale hardware trade from manufacturers' angle. Box 9421, care of "Plastics." 105-x8156

Energetic Plastic Engineer, 29, requires technical position; fully conversant in design of moulds (compression and injection), tools, plant layout, maintenance, good organizer. Box 9378, care of "Plastics." 105-x8063

Fully Qualified Designer (24) desires progressive post to utilize technical and artistic creative design ability; conversant with all branches of plastic industry, competent to handle industrial design, publicity and technical post. Home or abroad. Box 9347, care of "Plastics." 105-x8004

Plastic Moulding Shop Foreman or Manager seeks progressive position. Long practical experience on compression and injection. Would go any locality. Excellent references. Box 8790, care of "Plastics." 106-x5925

WANTED

Acetate and Nitrate. Sheet off-cuts and scrap plastic materials of every description wanted. We can arrange collection. Top prices paid. Lloyd's, 72 Bridge Street, Christchurch, Hants. Phone, Christchurch 504. zzz-51

Phenol. Advertiser requires regular supplies of phenol for own consumption. Full particulars of quantities and grades available to Box 8723, care of "Plastics." 105-5291

Wholesalers who are distributors of perspex and plastic goods throughout the country, invite manufacturers to contact them with their products. Apply, Kanby Products, 93 Turnmill Street, London, E.C.1. Cle 6065-8, 291. 105-x5409

Wanted—*contd.*

Wanted Casein Scrap or Waste. Are sending bags for collection. The Oilcakes and Oilseeds Trading Co., Ltd., Stone House, Bishopsgate, London, E.C.2. 106-5622

Urea and Phenol Moulding Powder in all colours. Large or small lots. Box 9035, care of "Plastics." zzz-371

Celluloid S/Transp., .020-in./.030-in. sheets, required immediately. Convex, Ltd., 41 Brecknock Road, N.7. Gul 4877. 105-30

Manufacturing opticians would like to contact manufacturers of acetate sheeting for spectacle-frame making. Box 9282, care of "Plastics" 105-x7145

Plastic toy wheels, all sizes, urgently required. "Betty Bashall Toys," Thames Ditton. 105-x8215

Distributors wish to contact manufacturers of plastic material and perspex. Box 9467, care of "Plastics." 105-x8939

Injection moulding machines wanted. Box 9548, care of "Plastics." 105-x9214

Urea moulding powder wanted, any price paid. Box 9547, care of "Plastics." 105-x9214

Permanent Hair Waving Bakelite heater parts wanted, any make, up to 10,000 or more, cash payment, urgent. Box 9484, care of "Plastics." 105-x8978

Perspex Scrap Transparent, ⅛ in. thick, minimum size 7½ ins. by 1 in., required, large quantities. Quotation and offers to Box 9554, care of "Plastics." 105-13

Wanted, several 100-ton hydraulic moulding presses, down-stroking, pre-filler type preferred. Full details, make, condition and price to Box 9555, care of "Plastics." 105-11

Modern Extruding Machines, large size, Francis Shaw or similar. Box 8328, care of "Plastics." 109-5943

Wanted, first-quality P.V.C. sheeting in large quantities. Please quote lowest prices, stating delivery times, with quantities and samples, to Deako Exports, 2 Lancaster Drive, London, N.W.3. 105-26

Merchants (Export) want to get in touch with manufacturers who are interested in exporting to India, Near and Far East. Large orders can be placed. Box 9045, care of "Plastics." 105-25

Rings. Advertiser requires regular supplies of plastic rings, 1½-in. inside diameter, or similar size. Box 9231, care of "Plastics." 105-x7079

Electric lamp bases. Lamp-shade manufacturer seeks competitive bulk supplies of attractive lamp bases of all types, including perspex, casein, wood, pottery, etc. Box 8717, care of "Plastics." 105-5288

MISCELLANEOUS

Pulverizing and Grading. Reduction of most thermoplastics down to 200 mesh undertaken by Dohm, Ltd., 167 Victoria Street, London, S.W.1. 108-4533

Factory Time Recorders. Service rental. Phone, Vigilant 4731. Time Recorder, Supply and Maintenance Co., 28 Mayfield Road, Sutton, Surrey. 113-5v65

Polyglot Translation Service, Ltd., Terminal House, 52 Grosvenor Gardens, London, S.W.1. Phone, Sloane 7059. Translations of every description. All languages. 107-5066

Grained moulding plates and rollers any pattern. J. Martin and Sons, Ltd., Park Street, Ardwick, Manchester, 12. 110-4421

Moulds, dies, jigs and fixtures for synthetic rubber and plastics made by British Rectifiers Eng. Co. (Cheltenham), Ltd., Vernon Place, Cheltenham. 105-x5137

Limited Quantity solid rubber-tyred steel wheels in excellent condition, 16 ins. dia., with solid rubber tyres, approximately 1½ ins. thick by 2⅝ ins. wide by approximately 19 ins. overall. Fitted with ball races 1 9/16-in. bore. Ideal for portable plant, concrete mixers, crushers, etc. Price 60s. per pair delivered; £5 10s. per set of four delivered or pro rata. Cash with order. Reynolds, Mann Place, Domestic Street, Leeds, 11. 107-5619

Quantity of scrap P.V.C., suitable for injection moulding; offers. Apply, Box 9639, care of "Plastics." 105-28

Acetate Scrap, approximately six tons for sale, mostly black, not sheet. Samples on request ex Birmingham. Box 9229, care of "Plastics." 105-x7080

Are buyers of formalised and unformalised casein waste, sending bags for collection. The Oilcakes and Oilseeds Trading Co., Ltd., Stone House, Bishopsgate, London, E.C.2. 105-15

Monomarks. Permanent London Address. Letters redirected, 5s. p.a. Write, Monomark BM/MONO76, W.C.1. 110-5942

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OF THE HIGHEST WORKMANSHIP
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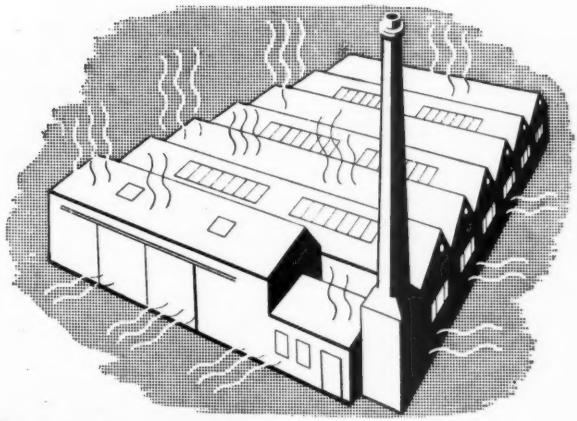

Don't let that heat escape!

VERY VALUABLE WORK has already been done to insulate pipes and tanks by lagging, but it is probable that insufficient attention is still given in Works and Factories to the efficient insulation of whole buildings.

Specialist advice on this vital question is available in the Fuel Efficiency Bulletin NO. 12, "THERMAL INSULATION OF BUILDINGS," obtainable from your Regional Office of the Ministry of Fuel and Power.

POINTS TO REMEMBER ABOUT HEATING

1 Once a building has been heated up to the necessary temperature, fuel is only needed to *maintain* that temperature.

2 The speed at which a building cools (due to the escape of heat by various means) governs the amount of fuel which is required to replace the escaping heat and maintain the temperature.

3 Adequate insulation reduces the heat loss and, hence, less fuel is required to maintain the temperature. And, remember, the building will be cooler in summer.

Remember . . .
effective insulation cuts fuel consumption

ISSUED BY THE MINISTRY OF FUEL AND POWER

FEBRUARY, 1946. Vol. X. No. 105 **Plastics** ONE SHILLING & SIXPENCE

THE SEVEN AGES OF PLASTICS MAN—1.

Shakespeare's famous lines are to-day a little dated in their terms of reference—we attempt to re-state the great dramatist's theme with 'modern instances'...

At first the Infant . . .

taking his ablutions in a plastics bath . . . supping his 'elevenses' from a plastics beaker . . . cutting his molars on a plastics teething ring . . . doing his little business on a plastics nursery chamber. Right from the start the infant of to-day makes acquaintance with plastics goods, of which in the years ahead he will use and acquire increasing types and numbers. Forward-looking plastics manufacturers, planning to cater for this infant's growing needs, are offered by Erinoid a right-from-the-start experience which is available without stint.

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